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# A Study of Fatal Approach-and-landing Accidents Worldwide, 1980–1996

Special FSF ALAR Task Force Report

FLIGHT SAFETY FOUNDATION
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# Flight Safety Digest

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## In This Issue





*Flight Safety Foundation (FSF) is an international membership organization dedicated to the continuous improvement of flight safety. Nonprofit and independent, FSF was launched in 1945 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 660 member organizations in 77 countries.*

# A Study of Fatal Approach-and-landing Accidents Worldwide, 1980–1996

***Study Commissioned by the U.K. Civil Aviation Authority***
***Safety Regulation Group***
***for***
***Flight Safety Foundation***

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*Ronald Ashford*
*Aviation and Safety Consultant*
*Accident Analysis Group*
*U.K. Civil Aviation Authority*

*Ronald Ashford's career in aviation began in 1953 with the de Havilland Aircraft Co., where he was a flight development engineer. After service in the Royal Air Force as a pilot officer, he returned to de Havilland — later Hawker Siddeley Aviation — as a flight test engineer on the Comet jet. In the U.K. Civil Aviation Authority (CAA) he held posts including head of flight engineering, head of the flight department, director general, airworthiness, and head of operational safety. He was appointed group director safety regulation and a CAA Board Member, and served as a member and chairman of the executive board of the European Joint Aviation Authorities. After leaving the CAA in 1992, he became Secretary-General of the Joint Aviation Authorities until 1994. Since then, he has worked as an aviation and safety consultant. During his career, Ashford has received numerous honors and awards including the 1992 Flight Safety Foundation/Aviation Week and Space Technology Distinguished Service Award.*

# Contents

# Executive Summary

This report summarizes an analysis of fatal accidents to jet and turboprop airplanes that occurred during approach and landing between 1980 and 1996 inclusive. The sample covered 287 fatal accidents involving 7,185 fatalities to passengers and crew members and was based on the U.K. Civil Aviation Authority (CAA) database for its *Global Fatal Accident Review*. The primary conclusions of the analysis were:

1. Both the number of accidents and the number of fatalities showed an increasing trend overall. If the trend continues, by 2010 there will be 23 fatal approach-and-landing accidents (ALAs) with a total of 495 fatalities annually involving Western-built aircraft (commercial jets, business jets and turboprop airplanes) and operators, other than those of the Commonwealth of Independent States (C.I.S.);

2. A disproportionate number of ALAs occurred on flights without passengers (freight, ferry and positioning); the accident rate was judged to be nearly eight times higher than on passenger flights;

3. Seventy-five percent of the ALAs occurred when a precision approach aid was not available or was not used;

4. A disproportionate number of the accidents occurred at night; the accident rate at night is estimated to be three times that for day;

5. The fatal ALA rate for Western-built jets (excludes business jets) was highest for operators from Africa (2.43 per million flights), South America and Central America (1.65), and Europe other than the Joint Aviation Authorities (JAA) full-member countries (1.64). Australasian operators had no ALAs in the period;

6. Full-member JAA countries in Europe had a fatal ALA rate for Western-built jets ten times lower than the other European countries;

7. The two most common primary causal factors, and most common of all causal factors, in ALAs were those in which the approach was continued below decision height or minimum descent altitude when no visual cues were available, and lack of positional awareness in the air, often resulting in a controlled-flight-into-terrain accident;

8. Aircraft built and operated in the Union of Soviet Socialist Republics or the C.I.S. (based on data for 1990–1996 only) had "press-on-itis" as the most common causal factor in ALAs, even though this was only sixth in the overall ranking; and,

9. The most frequent circumstantial factors were "nonfitment of presently available safety equipment" (generally ground-proximity warning system) and "failure in crew resource management." "Lack of ground aids" was cited in at least 25 percent of ALAs for all classes of aircraft.

# A Study of Fatal Approach-and-landing Accidents Worldwide, 1980–1996

***A study commissioned by the U.K. Civil Aviation Authority for Flight Safety Foundation examined in detail 287 fatal approach-and-landing accidents. Among the findings, were that 75 percent of the accidents occurred when a precision approach aid was not available or was not used; a disproportionate number of the accidents occurred at night; there were significant differences in the accident rates among world regions; and the leading causal factors were continuing the approach below decision height or minimum descent altitude in the absence of visual cues, and lack of positional awareness in the air.***

## 1.0 Introduction

Flight Safety Foundation (FSF) has focused attention on approach-and-landing accidents (ALAs) as one of its major safety initiatives. In discussion in the FSF international Approach-and-landing Accident Reduction (ALAR) Task Force, it was agreed that the U.K. Civil Aviation Authority (CAA) database for its *Global Fatal Accident Review*[1] could be used as a starting point for a study of the global fatal-accident experience during approach and landing of jet and turboprop airplanes having greater than 5,700 kilograms (12,500 pounds) maximum takeoff weight (MTOW). The *Global Fatal Accident Review* analyzed 621 fatal accidents that occurred between 1980 and 1996 inclusive and, from these, 287 (46 percent) were judged to be in the approach-and-landing phases of flight; the database of these 287 accidents forms the basis of this study, which was commissioned by the CAA for the Foundation.

## 2.0 The Accident Analysis Group

To conduct its accident review, the CAA formed an Accident Analysis Group (AAG) early in 1996. The group comprised seven researchers, each having extensive aeronautical experience gained in both the aviation industry and the regulatory environment. The researchers brought to the AAG first-hand knowledge, for example, in the following areas:

- Commercial airline operations;
- Flight testing, handling and performance;
- Systems and structural design;
- Human factors and flight-deck design;
- Risk/safety analysis techniques;
- Cabin safety and survivability;
- Regulatory/legal procedures; and,
- Maintenance.

The AAG was established to study all worldwide fatal accidents to jet and turboprop airplanes having greater than 5,700 kilograms MTOW that occurred since 1980 during public transport, business, commercial training and ferry/positioning flights. The following were excluded from the study:

- Piston-engine aircraft;
- Accidents resulting from acts of terrorism or sabotage;
- Fatalities to third parties not caused by the aircraft or its operation;
- Eastern-built aircraft and operators from the Union of Soviet Socialist Republics (U.S.S.R.) or Commonwealth of Independent States (C.I.S.) prior to 1990, because information from these countries was unavailable or limited at that time; and,
- Military-type operations or test flights.

Summaries of the accidents were obtained from the *World Aircraft Accident Summary*.[2] The summaries were usually brief and were supplemented with other information when required and available. At the AAG meetings, causal and circumstantial factors were discussed for each accident, and a consensus was reached on the factors to be allocated. These factors and any consequences were then recorded for each accident and entered in a fatal-accident database for future analysis. The AAG decided to assess all worldwide fatal accidents, unlike other studies in which only accidents where substantial information was available were reviewed; this was done to avoid any bias in the analysis toward accidents that have occurred in nations where detailed investigations are conducted and reports are issued. More details of the AAG approach are contained in Reference 1.

# 3.0 Accident Assessment

## 3.1 The Review Process

The review process accomplished by the AAG involved reaching consensus views to establish which causal factors, circumstantial factors and consequences occurred in each accident, together with an assessment of the level of confidence in the information available. In addition, a single primary causal factor was selected from the number of causal factors identified. Numbers of flights were also obtained from Airclaims (publisher of the *World Aircraft Accident Summary*) and other available sources.

## 3.2 Causal Factors

A causal factor was an event or item that was judged to be directly instrumental in the causal chain of events leading to the accident. An event might be cited in the accident summary as being a causal factor, or it might be implicit in the text. Whenever an official accident report was quoted in the accident summary, the AAG used any causal factors stated therein for consistency; additionally, as stated above, the AAG selected *one primary causal factor for each accident* (though this proved to be difficult for some accidents). Where the choice was contentious, the group agreed on a particular method to select one primary causal factor, and then applied this method consistently to all other similar situations.

The causal factors were listed in generic groups and then broken down into specific factors, e.g., one causal group was “aircraft systems” and one of the several specific factors in this group was “system failure affecting controllability.” The full list is shown in Appendix 1.

An accident could be allocated any number of causal factors from any one group and any combination of groups. In a single accident, the highest number of causal factors recorded was 10, which was allocated to an aircraft that undershot the runway.

## 3.3 Circumstantial Factors

A circumstantial factor was an event or item that was judged not to be directly in the causal chain of events but could have contributed to the accident. These factors were present in the situation and were believed to be relevant to the accident, although not directly causal. For example, it was useful to note when an aircraft had made a controlled flight into terrain (CFIT) and it was not fitted with a ground-proximity warning system (GPWS). Because GPWS was not mandatory for all aircraft in the study and an aircraft can be flown safely without it, the nonfitment of GPWS in a CFIT accident was classed as a circumstantial factor rather than a causal factor.

“Failure in crew resource management (CRM),” when judged to be relevant, was in some situations allocated as a circumstantial factor and in others as a causal factor. The former was chosen when the accident summary did not clearly cite, or the data point to, CRM as a causal factor, but the AAG felt that had the CRM been to a higher standard, the accident might have been prevented. For example, CFIT during descent might have been avoided by good crew CRM (cross-checking by crew members, better coordination and division of duties, etc.), but the accident report or data might not have given sufficient evidence that CRM failure was a causal factor.

Circumstantial factors, like causal factors, were listed in generic groups and then broken down further into specific factors. The full list is shown in Appendix 1. For causal factors, an accident could be allocated any number of circumstantial factors from any one group and any combination of groups. The highest number of circumstantial factors recorded in a single accident was seven.

## 3.4 Consequences

A list of consequences was used to record the outcomes of the fatal accidents in terms of collisions, structural failure, fire, fuel exhaustion and other events. It was important to keep a record of the consequences because all fatal accidents consist of a chain of events with a final outcome resulting in fatalities. In some accidents, it can be just as important to know what happened as why or how it happened, because a particular combination of causal factors on one day may lead to a fatal accident, while on another day, result in only a minor incident. In many events, the consequence is all that is remembered about a particular accident. The consequences are listed in Appendix 1. The highest number of consequences recorded in a single accident was five.

### 3.5 Level of Confidence

The AAG also recorded the level of confidence for each accident. This could be high, medium or low and reflected the group's confidence in the accident summary and the factors allocated. It was not a measure of confidence in the allocation of individual factors but of the group's analysis of the accident as a whole. Alternatively, if the group believed that there was not enough substantive information in the accident summary (and there was no possibility of obtaining an official accident report), then there was a fourth level of confidence — insufficient information. For these accidents, no attempt was made to allocate causal factors, although there might have been circumstantial factors such as poor visibility that appeared to be relevant. Accidents with insufficient information were included in the analysis with allocated consequences (and sometimes circumstantial factors), even though there were no primary or other causal factors.

### 3.6 Summary of Assessments

There were 64 possible causal factors, 15 possible circumstantial factors and 15 possible consequences, and each accident was allocated as many factors and consequences as were considered relevant. The group could allocate any combination of factors, although some factors are mutually exclusive. For example, factors A2.3 ("failure to provide separation in the air") and A2.4 ("failure to provide separation on the ground") would not be allocated to the same accident because the aircraft involved were either in the air or on the ground.

The recording of factors was based on judgments made on the available data, to ascertain the cause of the accident rather than to apportion blame.

### 3.7 Accident Rates

Absolute numbers of accidents are obviously not a good indication of safety standards and are of no comparative value until they are converted to accident rates. For this purpose, it is possible to present the number of accidents per hour, per passenger-kilometer, per tonne-kilometer, etc., but the rate per flight is considered to be clearly the most useful indicator[3] and is used in this study.

The great majority of accidents (90 percent) occur in the phases of flight associated with takeoff and landing, and the length of the cruise phase has little influence on the risk. If you consider two operations with similar safety in the context of takeoff, approach and landing, of which one involves 10-hour flights and the other one-hour flights, to use a "per-hour" basis for the accident rate would give the former operation an accident rate that is close to one tenth of the latter (short-haul) operation; this was felt to be misleading. The fundamental objective is to complete each flight safely, regardless of its duration.

## 4.0 Limitations of the AAG's Database

As with all statistics, care should be taken when drawing conclusions from the data provided. Only fatal accidents have been included in this study and therefore important events, including nonfatal accidents, serious incidents and "airprox" (insufficient separation between aircraft during flight) reports have not been covered. It is important to recognize these limitations when using the data.

The aggregated nature of the accident data, based on 287 accidents, tends to overcome errors of judgment, if any, made in analyzing individual accidents. A few errors of judgment would be unlikely to change the overall conclusions, especially because such errors might tend to balance one another.

## 5.0 Worldwide Results

Because of the lack of information on the numbers of flights worldwide, accident rates have not been included in this section. Nevertheless, utilization data were available for Western-built jets, and accident rates are included in section 10.

### 5.1 Fatal Accidents by Year

The group studied 287 worldwide fatal accidents during approach and landing that occurred between 1980 and 1996 inclusive. The numbers of fatal ALAs are shown by year in Figure 1 (page 7).

ALAs to Eastern-built aircraft and operators from the U.S.S.R. or C.I.S. were not included prior to 1990 because information was not available, was limited or was scarce.

There was an average of 12.1 accidents per year for the non-C.I.S. accidents in the first eight years of the study and 16.6 accidents per year in the last eight years; this shows a marked growth in the number of accidents. The average growth (best mean line) is 0.37 accidents per year; if this growth continued one could expect 23 fatal accidents to Western-built and Western-operated jets and turboprops (including business jets) annually by 2010.

### 5.2 Fatalities by Year

The total ALAs resulted in 7,185 fatalities to passengers and crew members, an average of 25 fatalities per accident or 63 percent of the aircraft occupants, as shown in Figure 2 (page 8).

*(continued page 7)*

## Data Support Safety Actions Recommended by FSF Approach-and-landing Accident Reduction Task Force

Flight Safety Foundation (FSF) presented the conclusions and recommendations of its work-in-progress to prevent approach-and-landing accidents (ALAs), during its 43rd annual Corporate Aviation Safety Seminar (CASS), May 5–7, 1998, in Hartford, Connecticut, U.S.

"There is a high level of confidence in these conclusions and recommendations," said Pat Andrews, manager, global aircraft services, Mobil Business Resources Corp., and co-chair of the Operations and Training Working Group under the FSF international Approach-and-landing Accident Reduction (ALAR) Task Force. "Our confidence is based upon analysis of ALAs and a confidence check accomplished through the assessment of crew performance in line audits conducted under Professor Robert Helmreich at the University of Texas."

The task force's primary goal is to reduce commercial jet aircraft ALAs by 50 percent within five years after the task force's final recommendations, which are applicable to most aircraft operations, including business/corporate jet operations. Comprehensive ALA data have been collected and analyzed by the U.K. Civil Aviation Authority (CAA) in the study commissioned for the Foundation: "Study of Fatal Approach-and-landing Accidents 1980–1996." The study includes fatal ALAs worldwide for both jet and turboprop aircraft with a maximum takeoff weight greater than 12,500 pounds (5,700 kilograms).

"Available data make clear that our greatest efforts to prevent ALAs must be in Africa, Latin America and Asia," said Andrews.

The operations group, in developing its conclusions and recommendations, targeted all operations occurring from the commencement of an instrument approach or a visual approach, including circling, landing and missed-approach procedure.

Included in the group's recommendations are proposed tools to further help prevent ALAs. A document would provide comprehensive principles and guidelines to reduce risk associated with approach and landing operations, including specific information for management, flight operations, flight crews, dispatch/schedulers, air traffic controllers and airport managers. Planning guides for risk assessment, an educational video program and a CEO briefing are other proposed tools.

The nine conclusions and their respective recommendations are below:

1. **Establishing and adhering to adequate standard operating procedures (SOPs) and crew resource management (CRM) processes improves approach and landing safety.**

   - States should mandate and operators should develop/implement SOPs for approach and landing operations;
   - Operators should develop SOPs that permit their practical application in a normal operating environment; input from flight crews is essential in the development and evaluation of SOPs;
   - Operators should provide education and training that enhance flight crew decision-making and risk management (error management); and,
   - Operators should implement routine and critical evaluation of SOPs to determine the need for change.

2. **Improving communication and mutual understanding between air traffic control personnel and flight crews of each other's operational environment will improve approach and landing safety.**

   *Specific recommendations are being developed to support this conclusion. Nevertheless, this conclusion suggests that CRM must be broadened to include a better-managed interface between flight crews and air traffic control personnel. Analysis reveals that compromises to approach and landing safety (e.g., rushed approaches) often result from misunderstanding or lack of knowledge about each other's operational environment.*

3. **Unstabilized and rushed approaches contribute to ALAs. Operators should define in their flight operations manuals the parameters of a stabilized approach and include at least the following:**

   1. Intended flight path;
   2. Speed;
   3. Power setting;
   4. Attitude;
   5. Sink rate;
   6. Configuration; and,
   7. Crew readiness.

*A suggested definition or policy that might be considered by operators:*

All flights shall be stabilized by 1,000 feet (305 meters) height above touchdown (HAT). An approach is considered stabilized when the following criteria are met:

- The aircraft is on the correct flight path;
- Only small changes in heading and pitch are required to maintain the flight path;
- The aircraft speed is not more than $V_{ref}$ +20 knots indicated airspeed (KIAS) and not less than $V_{ref}$ -5 KIAS;
- The aircraft is in approach or landing configuration. Note that many light twin-engine airplanes have limited single-engine go-around capability and that they should not be configured for landing until the landing is assured;
- Sink rate is no more than 1,500 feet (457.5 meters) per minute;
- Power setting is minimum specified for type of aircraft; and,
- All briefings and checklists have been performed.

*Specific types of approaches are considered stabilized if they also fulfill the following:*

- Instrument landing system (ILS) approaches — must be flown within one dot of the glide path or localizer, and a Category II approach or Category III approach must be flown within the expanded localizer band;
- Visual approaches — wings must be level on final when the aircraft reaches 500 feet (152.5 meters) HAT;
- Circling approaches — wings must be level on final when the aircraft reaches 300 feet (91.5 meters) HAT.

- Corporate policy should state that a go-around is required if the aircraft becomes unstabilized during the approach. Training should reinforce this policy.
- Before descent, a checklist-triggered risk assessment by the crew for the upcoming approach should be company SOP. Prior to commencement of the approach, the crew should confirm the risk assessment;
- The implementation of constant-angle and rate-of-descent procedures for nonprecision approaches should be expedited globally; and,
- Training should be made available to flight crews for learning proper use of constant-angle descent procedures as well as approach-design criteria and obstacle-clearance requirements.

**4. Failure to recognize the need for and to execute a missed approach when appropriate is a major cause of ALAs.**

- Company policy should specify go-around gates for approach and landing operations. Parameters should include:
  - Visibility minimums required prior to proceeding past the final approach fix (FAF) or the outer marker (OM);
  - Assessment at FAF or OM of crew readiness and aircraft readiness for the approach;
  - Minimum altitude at which the aircraft must be stabilized; and,
- Companies should declare and support no-fault go-around and missed-approach policies.

**5. The risk of ALAs is higher in operations conducted during conditions involving:**

1. Low light;
2. Poor visibility;
3. The likelihood of optical illusions; and,
4. Wet or otherwise contaminated runways.

- Tactical use should be made of a risk-assessment tool/checklist to identify hazards, the associated risks and appropriate procedures to reduce risks;
- Operators should develop procedures to assist crews in planning and controlling approach angle and rate of descent during approaches; and,
- Operators should develop a policy requiring the use of all available navigation and approach aids for each approach flown.

**6. Using the radio altimeter as an effective tool will prevent ALAs.**

- Educational tools are needed to improve crew awareness of radio-altimeter operation and benefits;
- Companies should state that the radio altimeter is to be used, and specify procedures for its use; and,
- Manufacturers should design equipment that allows for native-language callouts.

7. **When the pilot-in-command (PIC) is the pilot flying (PF), and the operational environment is complex, the task profile and workload reduce PF flight management efficiency and decision-making capability in approach and landing operations.**

   - There should be a clear policy in the operator's manual defining the role of the PIC in complex and demanding flight situations; and,

   - Training should address the practice of transferring PF duties during operationally complex situations.

8. **In-flight monitoring of crew/aircraft parameters (e.g., flight operations quality assurance [FOQA] program) identifies performance trends that operators can use to improve the quality of approach and landing operations. Performance improvement will result only if these data are managed sensitively and deidentified.**

   - FOQA should be implemented worldwide in tandem with information-sharing partnerships such as Global Analysis and Information Network (GAIN), British Airways Safety Information System (BASIS) and Aviation Safety Action Programs (ASAP). Deidentification of data (i.e., pilots cannot be identified) must be a cardinal requirement;

   - Examples of FOQA benefits (safety and cost reductions) should be publicized widely; and,

   - A process should be developed to bring FOQA and information-sharing partnerships to regional airlines and business aviation.

9. **Global sharing of aviation information decreases the risk of ALAs.**

   - Standardized global aviation phraseology should be used by all pilots and air traffic control personnel;

   - FOQA and information-sharing partnerships should be implemented worldwide;

   - Deidentification of aviation information data sources must be a cardinal requirement; and,

   - Public awareness of the importance of information sharing must be increased in a coordinated, professional and responsible way.

The FSF ALAR Task Force was created in June 1996 as a follow-on to the FSF international Controlled-flight-into-terrain (CFIT) Task Force. Both task forces have received widespread support from the aviation industry worldwide, including the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA).

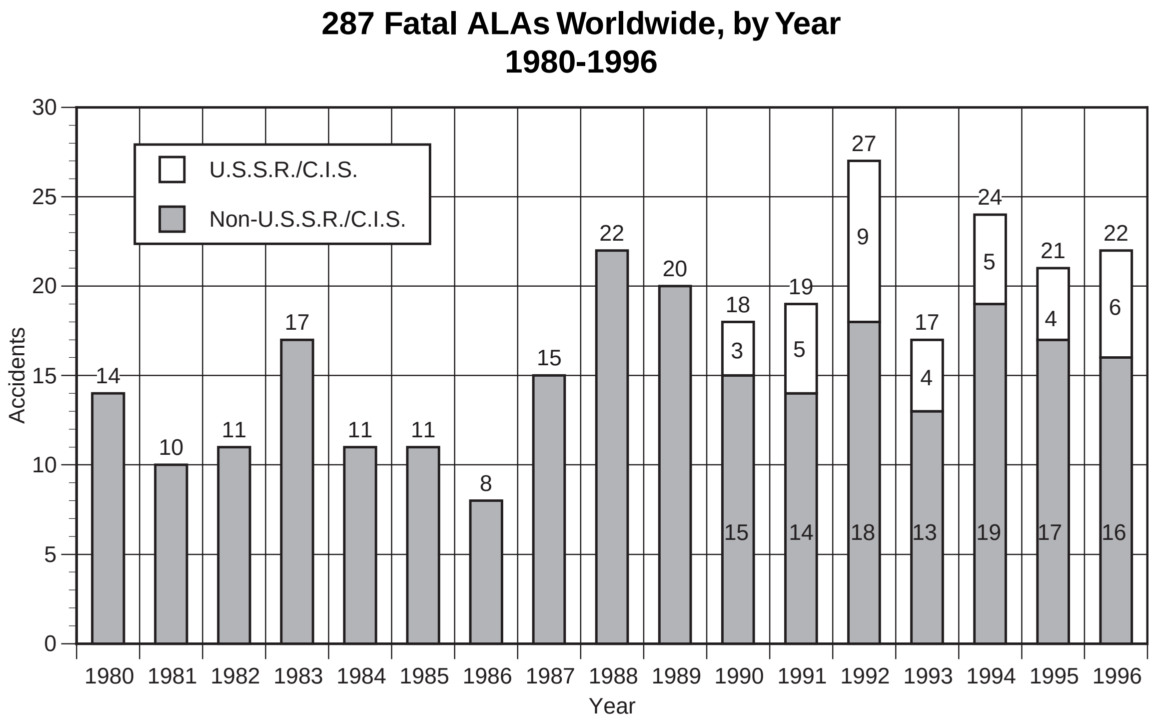
Capt. Erik Reed Mohn, manager, governmental and external affairs, Scandinavian Airlines System (SAS) Flight Academy, co-chairs the operations group, which later created the Data Acquisition and Analysis Working Group to focus on analysis of ALA data and associated research. The data group is co-chaired by Ratan Khatwa, Ph.D., Rockwell-Collins, and Helmreich. Jean-Pierre Daniel, Airbus Industrie, chairs the Equipment Working Group, which was created in 1996 with the operations group, and will present detailed findings later this year.

The operations group includes representatives from AlliedSignal, Airbus Industrie, Air Line Pilots Association International (ALPA), Air Transport Association of America, American Airlines, AMR Eagle, Amsterdam Airport Tower, Amsterdam Airport Schiphol, Avianca, Avianca-SAM, Boeing Commercial Airplane Group, British Airways, China Southern Airlines, Delta Air Lines, Garuda Airlines, Hewlett-Packard, ICAO, KLM Cityhopper, Mexicana Airlines, National Research Laboratory (NLR)–Netherlands, Pakistan International Airlines, Rockwell-Collins, SAS, Transportation Safety Board (TSB) of Canada, University of Texas, U.S. National Transportation Safety Board (NTSB), US Airways and U.S. Aviation Underwriters.

The data group has undertaken three separate studies: the U.K. CAA's study of ALAs; a separate comprehensive study of 75 official ALA investigation reports, using a methodology that included CAA taxonomy, and found a high correlation between the CAA study of ALAs and the comprehensive study of 75 specific ALA accidents; and a study of 3,000 line audits that aimed to identify pre-cursors of accidents during normal flight operations.

Based on the three studies, the data group formulated conclusions and recommendations in air traffic control, airport authorities, flight crews, flight operations management, regulatory authorities and accident-incident investigation authorities. All these data have been used to develop other task force recommendations.

The data group includes representatives from Airbus Industrie, ALPA International, American Airlines, Amsterdam Airport Schiphol, Amsterdam Airport Tower, Australian Bureau of Air Safety Investigation, Aviacsa Aeroexo, The Boeing Co., British Aerospace, British Airways, Continental Airlines, Cranfield University Safety Center, Dutch ALPA, FlightSafety Boeing, Honeywell, IATA, ICAO, International Federation of Air Line Pilot's Association, KLM Cityhopper, NLR - Netherlands, NTSB, Rockwell-Collins, Southwest Airlines, TSB of Canada, U.K. Air Accidents Investigation Branch, U.K. CAA, and University of Texas.♦




ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 1**

In 1992, there were 970 fatalities, almost twice the annual average of 540 of the years 1990–1996 (in which U.S.S.R./C.I.S. data are included).

In the first eight years of the study, there was an average of 300 fatalities per year for the non-U.S.S.R./C.I.S. accidents, compared with 428 for the last eight years. The "best mean line" growth was 6 percent per year. Though such growth continuing would lead to an annual average of 495 by 2010, there is reason to believe that the figures since 1992 may indicate improvement.

## 5.3 Phase of Flight

The group allocated one of 14 phases of flight to its analysis of worldwide accidents, based on accident information from Airclaims.[2] This study looks more closely at the accidents in just three of these phases of flight, as shown in Table 1. The selection of flight phase was based on judgment rather than precise criteria.

Those accidents that occurred in other closely related phases, i.e., descent, hold and go-around, were not included. The accidents are fairly evenly distributed among the three phases of flight considered.

**Table 1**
**287 Fatal ALAs Worldwide, By Phase of Flight 1980–1996**

| Phase of Flight | Fatal ALAs |
|---|---|
| Approach | 108 |
| Final approach | 82 |
| Landing | 97 |
| **Total** | **287** |

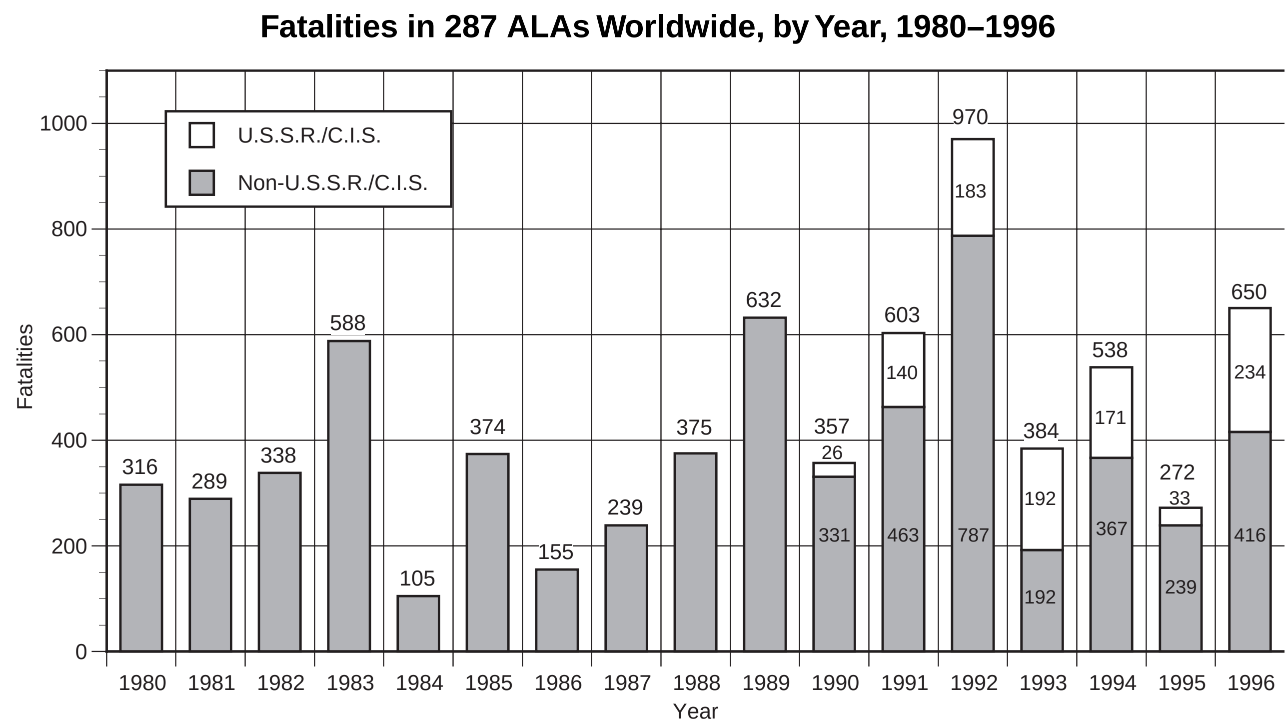
ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

## 5.4 Accident Locations by Region

The number of ALAs in each of the world regions in which the 287 fatal accidents occurred is shown in Table 2 (page 8). The figures in the right-hand column show the percentage of




ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 2**

**Table 2**
**287 Fatal ALA Locations, by Region***
**1980–1996**

| Region | Fatal ALAs | Percent of Region's Fatal Accidents |
|---|---|---|
| North America | 74 | 44% |
| South/Central America | 67 | 49% |
| Asia | 43 | 35% |
| Africa | 34 | 49% |
| Europe | 62 | 57% |
| Australasia | 7 | 50% |
| **Total** | **287** | |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

*Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

the fatal accidents in *all* phases of flight in the region that occurred during the three approach-and-landing flight phases.

The regions are those defined by Airclaims (Appendix 2). “Europe,” however, includes the U.S.S.R. and C.I.S.

To understand the full significance of these figures, one needs to know the numbers of relevant flights in each region and hence the accident rates; these figures are not currently available. (See section 10, page 13, for more comprehensive data on Western-built jets.)

The percentage of accidents occurring during approach and landing might be expected to reflect the frequency of bad weather, terrain problems and availability of precision approach aids. All regions, however, have figures of 50 percent ± 7 percent, except Asia, where such accidents are clearly a lower proportion of the total (35 percent).

### 5.5 Accidents by Region of Operator

The accidents are shown in Table 3 (page 9) by region of operator. Because of the marked difference in regulatory arrangements between the two groups, Europe has been divided into the Joint Aviation Authorities (JAA) full-member countries (see Appendix 3) and the “rest of Europe,” which includes JAA candidate members and nonmembers. (See 10.7, page 19.)

**Table 3**
**287 Fatal ALAs Worldwide, By Region* of Operator 1980–1996**

| Region | Fatal ALAs |
|---|---|
| North America | 78 |
| South/Central America | 67 |
| Asia | 42 |
| Africa | 31 |
| Europe | 64 |
| JAA full-member countries | 30 |
| All other European countries | 34 |
| Australasia | 5 |
| **Total** | **287** |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).

U.S.S.R. – Union of Soviet Socialist Republics
C.I.S. – Commonwealth of Independent States

JAA – Joint Aviation Authorities

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

* Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

The distribution of fatal accidents by region of operator is not markedly different from the distribution of accident locations by region.

Again, the numbers of flights flown by all of the classes of aircraft covered and by region are not currently available, so that it was not possible to present accident rates.

## 5.6 Service Type

The 287 fatal accidents occurred during the types of service shown in Table 4.

Though the actual numbers of flights for all classes of aircraft are not available, data indicate that there is a much higher accident rate on freight/ferry/positioning flights than on passenger flights. During the period 1990–1996 inclusive, 3.6 percent of the international and domestic flights during scheduled services of International Air Transport Association (IATA) members involved all-cargo flights.[4] CAA's data on fixed-wing air transport movements at U.K. airports[5] from 1986 to 1996 for aircraft having greater than 5,700 kilograms (12,500 pounds) MTOW showed that an average of 5 percent were all-cargo flights; there was a steady increase in this period from 4.4 percent in 1986 to 5.6 percent in 1996. The average for the period covered in this study (1980–1996) is therefore estimated to be about 4.6 percent for U.K. airports.

These indications suggest that, overall, the freight/cargo operations together with ferry and positioning flights represent about 5 percent of the number of flights carried out in commercial transport operations. This indicates that the fatal accident rate on freight, ferry and positioning flights (i.e., when no fare-paying passengers are on board the aircraft) is some eight times higher than that for passenger flights. This is a surprising and important conclusion considering that the safety and operational standards that should be applied to such flights are generally no different from those for passenger flights.

**Table 4**
**287 Fatal ALAs Worldwide, By Type of Service 1980–1996**

| Service | Fatal ALAs | Percent of 287 Fatal ALAs |
|---|---|---|
| Passenger | 177 | 62% |
| Freight/ferry/positioning | 73 | 25% |
| Business/other revenue | 30 | 10% |
| Training/other nonrevenue | 7 | 3% |
| **Total** | **287** | **100%** |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).
U.S.S.R. – Union of Soviet Socialist Republics
C.I.S. – Commonwealth of Independent States
Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

## 5.7 Aircraft Classes

The classes of aircraft involved in the accidents analyzed are shown in Table 5.

**Table 5**
**287 Fatal ALAs Worldwide, By Class of Aircraft 1980–1996**

| Class | Fatal ALAs | Percent of 287 Fatal ALAs |
|---|---|---|
| Western-built jets | 92 | 32% |
| Eastern-built jets | 16 | 6% |
| Western-built turboprops | 84 | 29% |
| Eastern-built turboprops | 19 | 7% |
| Business jets | 76 | 26% |
| **Total** | **287** | **100%** |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).

U.S.S.R. – Union of Soviet Socialist Republics
C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

Accidents involving Western-built jets are reviewed in more detail in section 10.

### 5.8 Type of Approach

In 169 (59 percent) of the accidents, the type of approach used was not known. The breakdown of the remainder is shown in Table 6.

**Table 6**
**118 Fatal ALAs Worldwide, By Type of Approach 1980–1996**

| Type of Approach | Fatal ALAs | Percent of 118 Fatal ALAs* |
|---|---|---|
| Visual | 49 | 41% |
| ILS or ILS/DME | 30 | 25% |
| VOR/DME | 16 | 13% |
| NDB | 11 | 9% |
| VOR | 10 | 8% |
| Other (SRA or DME) | 2 | 4% |
| **Total** | **118** | **100%** |

*Where the type of approach was known.

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).

U.S.S.R. – Union of Soviet Socialist Republics

C.I.S. – Commonwealth of Independent States

ILS – instrument landing system

DME – distance measuring equipment

VOR – very high frequency omnidirectional radio

NDB – nondirectional beacon

SRA – surveillance-radar approach

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

Of those accidents where the type of approach was known, only 25 percent occurred during approaches and landings where a precision approach aid was available. It is suspected that precision approach aids were not available in some of the accidents where no information on the type of approach was found; if so, then much more than 75 percent of ALAs occurred when a precision approach aid was not available or not used.

### 5.9 Night, Day, Twilight

It might be assumed that night approaches result in more difficulties caused, for example, by fewer visual cues or by spatial disorientation. Similarly, it is possible that the twilight hours could present particular problems. Where known, the ALAs have been allocated to day, night or twilight — the latter being broadly defined as times close to local sunrise and sunset. The results are shown in Table 7.

**Table 7**
**287 Fatal ALAs Worldwide, by Time of Day 1980–1996**

| Time | Fatal ALAs | Percent of 287 Fatal ALAs |
|---|---|---|
| Day | 143 | 50% |
| Night | 112 | 39% |
| Twilight | 5 | 2% |
| Not known | 27 | 9% |
| **Total** | **287** | **100%** |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).

U.S.S.R. – Union of Soviet Socialist Republics

C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

A global figure for the proportion of landings made at night is not known, but discussions with airlines and airfield operators suggest that the figure is about 20 percent to 25 percent. If this is correct, then the rate for ALAs at night is nearly three times that for day. No conclusion can be drawn from the twilight figure.

When ALAs are broken down by aircraft class, business jets — with 76 ALAs — suffered an even higher proportion of accidents at night. Of those 66 business-jet ALAs (87 percent) where the lighting conditions were known, 36 ALAs (55 percent) occurred at night and 27 ALAs (41 percent) occurred during daylight.

### 5.10 Level of Confidence

The level of confidence reflected the group's confidence in the completeness of the accident summary and consequently the factors allocated for each accident, as detailed in 3.5. Of the 287 fatal ALAs, 152 were allocated a high level of confidence, as shown in Table 8 (page 11).

Causal factors were allocated to all but the eight accidents (3 percent) where there was believed to be insufficient information. The factors from all of the other accidents (279) were used in the analysis. There was little difference in the proportion of accidents allocated given levels of confidence for each aircraft class, e.g., 53 percent and 61 percent of those involving Western-built jets and turboprops, respectively, were allocated high levels of confidence.

## 6.0 Analysis of Primary Causal Factors

### 6.1 Primary Causal Factors — Overall

In the accident review carried out by the AAG, any number of causal factors may have been allocated, with one identified to

**Table 8**
**Level of Confidence in Completeness of Accident Summary of 287 Fatal ALAs Worldwide**
**1980–1996**

| Level | Fatal ALAs | Percent of 287 Fatal ALAs |
|---|---|---|
| High | 152 | 53% |
| Medium | 104 | 36% |
| Low | 23 | 8% |
| Insufficient information | 8 | 3% |
| **Total** | **287** | **100%** |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).
U.S.S.R. – Union of Soviet Socialist Republics
C.I.S. – Commonwealth of Independent States
Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.
Source: U.K. Civil Aviation Authority/Flight Safety Foundation

be the primary causal factor. Of the 287 ALAs, eight were judged to have insufficient information available, leaving 279 for which causal factors were allocated.

The most frequently identified primary causal factors in the overall sample of 279 accidents are shown in Table 9.

**Table 9**
**Most Frequent Primary Causal Factors In 279 Fatal ALAs Worldwide**
**1980–1996**

| Primary Causal Factor*/** | Fatal ALAs | Percent of 279 Fatal ALAs |
|---|---|---|
| Omission of action/ inappropriate action | 69 | 24.7% |
| Lack of positional awareness in the air | 52 | 18.6% |
| Flight handling | 34 | 12.2% |
| "Press-on-itis" | 31 | 11.1% |
| Poor professional judgment/airmanship | 12 | 4.3% |
| **Total** | **198**** | |

*For which sufficient information was known to allocate causal factors.

**Some ALAs had primary causal factors not among the five most frequent primary causal factors.

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).
U.S.S.R – Union of Soviet Socialist Republics
C.I.S. – Commonwealth of Independent States
Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.
Source: U.K. Civil Aviation Authority/Flight Safety Foundation

These five most frequently identified primary causal factors (out of a possible 64) account for 71 percent of the accidents. All five primary causal factors are from the "crew" causal group, indicating that crew factors were involved.

In these ALAs, the most common primary causal factor, "omission of action/inappropriate action," generally referred to the crew continuing the descent below the decision height (DH) or minimum descent altitude (MDA) without visual reference, or when visual cues were lost. The second most frequent factor, "lack of positional awareness in the air," generally involved a lack of appreciation of the aircraft's proximity to high ground, frequently when the aircraft was not equipped with a GPWS and/or when precision approach aids were not available; these were generally CFIT accidents.

Considering the causal groups ("A" in Appendix 1), rather than individual factors, "crew" featured in 228 of the 279 accidents (82 percent), followed by "environmental" in 14 (5 percent).

The complete summaries of causal factors allocated, including primary causal factors, are shown in Appendix 4.

### 6.2 Primary Causal Factors by Aircraft Class

When each aircraft class is considered separately, there are considerable differences in the most frequently identified primary causal factors. Table 10 (page 12) shows the ranking of various primary factors for each class; the figures in parentheses are the percentages of the accidents for that aircraft class.

It is noteworthy that for the aircraft built and operated in the U.S.S.R./C.I.S., "press-on-itis" is the most frequent primary cause, but this is generally fourth in the ranking for other aircraft classes. "Flight handling" ranks first for Western-built turboprops, even though it is only third overall.

## 7.0 Analysis of All Causal Factors

### 7.1 All Causal Factors — Overall

As stated, the AAG allocated any number of causal factors to each accident. Frequently, an accident results from a combination of causal factors, and it is important to see the overall picture (the other contributing factors as well as the primary causal factor) rather than just the single primary factor. For this part of the analysis, primary factors have been included along with all others. The average number of causal factors allocated was 3.8. The largest number of causal factors allocated was 10.

The most frequently identified causal factors in the sample of 279 accidents are shown in Table 11 (page 13).

**Table 10**
**Ranking of Primary Causal Factors in 279 Fatal ALAs Worldwide, by Aircraft Class 1980–1996**

| Primary Causal Factor | Overall Ranking | Western-built Jets | Eastern-built Jets | Western-built Turboprops | Eastern-built Turboprops | Business Jets |
|---|---|---|---|---|---|---|
| Omission of action/ inappropriate action | 1 (24.7%) | 1 (27.4%) | = 2 (12.5%) | 3 (17.1%) | 2 (18.7%) | 1 (31.1%) |
| Lack of positional awareness in the air | 2 (18.6%) | 2 (16.5%) | = 2 (12.5%) | = 1 (19.5%) | 3 (12.5%) | 2 (20.3%) |
| Flight handling | 3 (12.2%) | = 3 (9.9%) | = 4 (6.3%) | = 1 (19.5%) | = 4 (6.3%) | 3 (9.5%) |
| “Press-on-itis” | 4 (11.1%) | = 3 (9.9%) | 1 (31.2%) | 4 (8.5%) | 1 (37.5%) | = 4 (5.4%) |
| Poor professional judgment/airmanship | 5 (4.3%) | 5 (5.5%) | • | = 6 (3.7%) | • | = 4 (5.4%) |
| Deliberate nonadherence to procedures | 6 (2.9%) | = 7 (2.2%) | • | = 8 (2.4%) | = 4 (6.3%) | = 6 (4.1%) |
| Wind shear/upset/ turbulence | 7 (2.2%) | = 7 (2.2%) | = 4 (6.3%) | = 6 (3.7%) | • | • |
| Failure in CRM (cross-check/coordinate) | 8 (1.8%) | = 14 (1.1%) | • | 5 (4.9%) | • | • |
| Icing | = 9 (1.4%) | • | • | = 11 (1.2%) | = 4 (6.3%) | = 8 (2.7%) |
| System failure • flight deck information | = 9 (1.4%) | = 14 (1.1%) | = 4 (6.3%) | = 11 (1.2%) | • | =10 (1.4%) |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States CRM – crew resource management • – No fatal ALAs were attributed to this primary causal factor in this class of aircraft.

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Note: The complete list of primary causal factors has been shortened for this table. Factors that ranked high in the overall list (first column) sometimes ranked lower for specific types of aircraft. In some instances, two or more primary causal factors occurred in equal numbers of accidents, and the factors were assigned equal rankings. For example, some columns may contain two 3s, three 4s, etc.
In several instances, a factor shown in the table occurred in equal numbers of accidents with a factor not shown because the factor not shown was not among those ranked 1 through 9 in the “overall ranking” column.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

The figures in the right-hand column indicate the proportion of the 279 accidents to which the particular causal factor was allocated; remember that each accident usually has several factors applied to it. Once again, all the five causal factors most frequently selected were in the “crew” causal group.

The three most frequently identified causal factors each appear in about 40 percent or more of all accidents.

### 7.2 All Causal Factors by Aircraft Class

The ranking of the various most frequent causal factors is shown for each aircraft class in Table 12 (page 14).

Again, “press-on-itis” appears as the most frequent, or equally most frequent, causal factor for aircraft built and operated in the C.I.S., whereas it ranked only sixth overall. “Deliberate nonadherence to procedures” is seen also to be more frequent for the C.I.S. aircraft than for Western-built and -operated jets; to a lesser extent, business jets also rank higher on this factor.

## 8.0 Analysis of Circumstantial Factors

### 8.1 Circumstantial Factors — Overall

As stated in 3.3, a circumstantial factor was an event or aspect that was not directly in the causal chain of events but could have contributed to the accident. The average number of circumstantial factors was 2.7. The most frequently identified circumstantial factors in the sample of 279 accidents are shown in Table 13 (page 15).

The “nonfitment of presently available safety equipment” referred, in the great majority of accidents, to the lack of GPWS or, in some cases, lack of enhanced GPWS of the type that is now (even if not at the time of the accident) available; this was intended to estimate how many accidents such equipment might prevent in the future.

“Failure in CRM” also ranked high as a causal factor. A judgment was made as to whether the lack of good CRM was actually one of the causes that led to the accident, in

**Table 11**
**Most Frequent Causal Factors In 279 Fatal ALAs Worldwide 1980–1996**

| Causal Factor* | Cited in Fatal ALAs | Percent of 279 Fatal ALAs |
|---|---|---|
| Lack of positional awareness in the air | 132 | 47.3% |
| Omission of action/ inappropriate action | 121 | 43.4% |
| Slow and/or low on approach | 109 | 39.1% |
| Flight handling | 81 | 29.0% |
| Poor professional judgment/airmanship | 68 | 24.3% |
| **Total** | **511**** | |

* For which sufficient information was known to allocate causal factors.

** Most ALAs had multiple causal factors.

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds).

U.S.S.R. – Union of Soviet Republics

C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

which case it was allocated as a causal factor, or inadequate CRM appeared to be present, and if it had been to a higher standard, might have helped to prevent the accident (i.e., a circumstantial factor).

### 8.2 Circumstantial Factors by Aircraft Class

The ranking of the most frequent circumstantial factors is shown for each aircraft class in Table 14 (page 15).

There is some consistency in the five circumstantial factors that occur most frequently, except for Eastern-built turboprops. The "nonfitment of presently available safety equipment" (essentially GPWS) was judged to be a factor in 47 percent of all ALAs. "Failure in CRM" was also a factor in at least 37 percent of all the aircraft groups. Lack of ground aids — basically, the lack of a precision approach aid or navigational aid — was an important factor (at least 25 percent of the accidents) across aircraft classes.

## 9.0 Analysis of Consequences

### 9.1 Consequences — Overall

As stated before, consequences are not seen as part of the causes of accidents, but are relevant to a complete understanding of the accident history. A full list of the 15 consequences considered is shown in Appendix 1. The average number of consequences allocated was 1.9. Consequences were allocated even to those accidents (eight) that the AAG considered to have insufficient information for the selection of causal or circumstantial factors. The most frequently identified consequences in this sample of 287 ALAs are shown in Table 15 (page 16).

"Collision with terrain/water/obstacle" and "CFIT" were the most frequent consequences. The former implied that control of the aircraft had been lost (i.e., "loss of control in flight" would also have been allocated), or severe weather or some other factor had contributed to the impact; "CFIT," on the other hand, was allocated when the aircraft was flown into the ground and under full control. Where the impact with terrain occurred in circumstances where it was not clear whether or not the aircraft was under control, the former consequence was applied; this almost certainly underestimates the number of CFIT accidents.

Postimpact fire occurred in nearly a quarter of the accidents (and probably occurred in more). It should be noted that "postimpact fire" was given as a consequence whenever it was known to have occurred. It also appears for some accidents as a causal factor; this indicates that in these accidents it was judged to have contributed to the fatalities. (See 7.2, page 12.)

"Undershoots" can be seen to have been involved in many fatal accidents; "overruns" were features of about half as many accidents — presumably because overruns are less often fatal, rather than because they occur less often.

### 9.2 Consequences by Aircraft Class

The ranking of the most frequent consequences is shown for each aircraft class in Table 16 (page 16).

The pattern of consequences is moderately consistent. "Collision with terrain/water/obstacle" is the most frequently cited consequence overall and in three of the five aircraft classes. But Eastern-built jets have "overrun" as a consequence at nearly twice the frequency of the overall sample.

## 10.0 Analysis of Western-built Jets

This section presents an analysis of Western-built jet airliner operations by world regions; business jets are in a separate class. Airclaims has provided utilization data, including numbers of flights flown annually for this category of aircraft. The fatal accident rates are shown in relation to the number of flights, which provide the most useful and valid criterion to indicate safety standards. (See 3.7, page 3.)

Ninety-two of the 287 fatal ALAs (32 percent) involved Western-built jets.

## Table 12
## Ranking of All Causal Factors in 279 Fatal ALAs Worldwide, by Aircraft Class 1980–1996

| Causal Factor | Overall Ranking | Western-built Jets | Eastern-built Jets | Western-built Turboprops | Eastern-built Turboprops | Business Jets |
|---|---|---|---|---|---|---|
| Lack of positional awareness in the air | 1 (47.3%) | 1 (44.0%) | = 1 (43.7%) | 2 (42.7%) | 2 (37.5%) | 1 (59.5%) |
| Omission of action/ inappropriate action | 2 (43.4%) | 1 (44.0%) | 3 (37.5%) | 1 (43.9%) | = 3 (31.2%) | 3 (45.9%) |
| Slow and/or low on approach | 3 (39.1%) | 3 (35.2%) | 4 (31.2%) | 4 (39.0%) | = 3 (31.2%) | 2 (47.3%) |
| Flight handling | 4 (29.0%) | 5 (27.5%) | = 6 (18.7%) | 3 (40.2%) | = 5 (25.0%) | 5 (21.6%) |
| Poor professional judgment/airmanship | 5 (24.3%) | 4 (30.8%) | = 9 (12.5%) | 7 (19.5%) | = 7 (18.7%) | 4 (25.7%) |
| "Press-on-itis" | 6 (21.5%) | 6 (17.6%) | = 1 (43.7%) | 6 (20.7%) | 1 (50.0%) | 6 (16.2%) |
| Failure in CRM (cross-check/coordinate) | 7 (15.8%) | 7 (16.5%) | = 6 (18.7%) | 5 (22.0%) | • | 8 (10.8%) |
| Postimpact fire | = 8 (11.8%) | = 8 (14.3%) | = 9 (12.5%) | = 8 (13.4%) | = 10 (12.5%) | 12 (6.8%) |
| Deliberate nonadherence to procedures | = 8 (11.8%) | = 17 (6.6%) | = 6 (18.7%) | 10 (11.0%) | = 5 (25.0%) | 7 (14.9%) |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). C.I.S. – Commonwealth of Independent States CRM – crew resource management • – No fatal ALAs were attributed to this causal factor in this class of aircraft.

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Note: The complete list of all causal factors has been shortened for this table. Factors that ranked high in the overall list (first column) sometimes ranked lower for specific types of aircraft. In some instances, two or more factors occurred in equal numbers of accidents, and the factors were assigned equal rankings. For example, some columns may contain two 3s, three 4s, etc. In several instances, a factor shown in the table occurred in equal numbers of accidents with a factor not shown because the factor not shown was not among those ranked 1 through 8 in the "overall ranking" column.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

### 10.1 Fatal Accidents by Year

The 92 fatal accidents are shown in Figure 3 (page 17).

The number of accidents per year in Western-built jets averages between five per year and six per year, with an increasing trend over the period of the study; the average growth (best mean line) is 0.11 accidents per year. One might hope, however, that the figures since 1992 indicate a decreasing trend.

### 10.2 Fatalities by Year

The 92 fatal accidents during approach and landing to Western-built jets between 1980 and 1996, inclusive, resulted in 4,696 fatalities to passengers and crew, as shown in Figure 4 (page 18). This gives averages of 51 fatalities per accident and 276 fatalities per year. The overall number of fatalities divided by the number of occupants (passengers and crew) in all the accidents gives a measure of average survivability; this figure is 61 percent.

In the first eight years of the 17-year period, there were 1,804 fatalities compared with 2,662 in the last eight years; this suggests a significantly worsening trend. The growth rate overall (best mean line) averages 4.5 fatalities per year. Both the number of accidents and the number of fatalities are growing by between 1 percent and 2 percent per year. A continuing increase in the number of accidents and the number of fatalities is likely to become unacceptable to the public, unless the trend is definitely checked or reversed.

### 10.3 Fatal Accidents by Region of Operator

The fatal ALAs for Western-built jets between 1980 and 1996 are shown in Figure 5 (page 18) by region of the operator; there were no such accidents in Australasia.

Europe is shown by the 19 full-member JAA countries in Europe and the other European countries. (See 10.7, page 19.)

### 10.4 Fatal Accident Rates by Region of Operator

When the numbers of flights are applied to give the fatal accident rates per million flights of Western-built jets for ALAs, the comparisons are different, as shown in Figure 6 (page 19).

## Table 13
## Ranking of Most Frequent Circumstantial Factors in 279 Fatal ALAs Worldwide 1980–1996

| Circumstantial Factor* | Cited in Fatal ALAs | Percent of 279 Fatal ALAs |
|---|---|---|
| Nonfitment of presently available safety equipment (GPWS, TCAS, wind-shear warning, etc.) | 132 | 47.3% |
| Failure in CRM (cross-check/coordinate) | 131 | 47.0% |
| Weather (other than poor visibility, runway condition) | 103 | 36.9% |
| Poor visibility | 89 | 31.9% |
| Lack of ground aids | 81 | 29.0% |
| **Total** | **536**** | |

*For which sufficient information was known to allocate circumstantial factors.
**More than one circumstantial factor could be allocated to a single accident.

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States
GPWS – ground-proximity warning system TCAS – traffic-alert and collision avoidance system CRM – crew resource management

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

## Table 14
## Ranking of Most Frequent Circumstantial Factors in 279 Fatal ALAs Worldwide, By Aircraft Class 1980–1996

| Circumstantial Factor | Overall Ranking | Western-built Jets | Eastern-built Jets | Western-built Turboprops | Eastern-built Turboprops | Business Jets |
|---|---|---|---|---|---|---|
| Nonfitment of presently available safety equipment (GPWS, TCAS, wind-shear warning, etc.) | 1 (47.3%) | 1 (44.0%) | = 1 (50.0%) | 2 (46.3%) | 7 (12.5%) | 1 (59.5%) |
| Failure in CRM (cross-check/coordinate) | 2 (47.0%) | 2 (41.8%) | = 1 (50.0%) | 3 (45.1%) | = 3 (37.5%) | 2 (56.8%) |
| Other weather (other than poor visibility, runway condition) | 3 (36.9%) | 4 (28.6%) | 3 (43.7%) | 1 (50.0%) | 1 (50.0%) | 5 (28.4%) |
| Poor visibility | 4 (31.9%) | 3 (31.9%) | = 5 (25.0%) | 4 (30.5%) | 6 (31.2%) | 3 (35.1%) |
| Lack of ground aids | 5 (29.0%) | = 5 (25.3%) | 4 (31.2%) | = 5 (26.8%) | = 3 (37.5%) | 4 (33.8%) |
| Inadequate regulatory oversight | 6 (23.7%) | = 5 (25.3%) | = 5 (25.0%) | 5 (26.8%) | 2 (43.7%) | 7 (13.5%) |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States
GPWS – ground-proximity warning system CRM – crew resource management TCAS – traffic-alert and collision avoidance system

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./ C.I.S. were not included for years before 1990.

Note: The complete list of most frequent circumstantial factors has been shortened for this table. Factors that ranked high in the overall list (first column) sometimes ranked lower for specific types of aircraft. In some instances, two or more factors occurred in equal numbers of accidents, and the factors were assigned equal rankings. For example, some columns may contain two 3s, three 4s, etc. In several instances, a factor shown in the table occurred in equal numbers of accidents with a factor not shown because the factor not shown was not among those ranked 1 through 6 in the “overall ranking” column.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

## Table 15
## Most Frequently Identified Consequences in 287 Fatal ALAs Worldwide 1980–1996

| Consequence | Cited in Fatal ALAs | Percent of 287 Fatal ALAs |
|---|---|---|
| Collision with terrain/water/obstacle | 131 | 45.6% |
| Controlled flight into terrain (CFIT) | 120 | 41.8% |
| Loss of control in flight | 74 | 25.8% |
| Postimpact fire | 65 | 22.6% |
| Undershoot | 50 | 17.4% |
| **Total** | **440*** | |

*Some accidents had multiple consequences.

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R. and C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

## Table 16
## Ranking of Identified Consequences in 287 Fatal ALAs Worldwide, by Aircraft Class 1980–1996

| Consequence | Overall Ranking | Western-built Jets | Eastern-built Jets | Western-built Turboprops | Eastern-built Turboprops | Business Jets |
|---|---|---|---|---|---|---|
| Collision with terrain/water/obstacle | 1 (44.6%) | 1 (48.9%) | = 2 (31.2%) | 1 (50.0%) | 1 (47.8%) | 2 (39.5%) |
| Controlled flight into terrain (CFIT) | 2 (41.8%) | 2 (34.8%) | 1 (56.2%) | 2 (40.5%) | = 2 (31.6%) | 1 (51.3%) |
| Loss of control in flight | 3 (25.8%) | 4 (22.8%) | = 6 (6.2%) | 3 (38.1%) | = 2 (31.6%) | 4 (18.4%) |
| Postimpact fire | 4 (22.6%) | 3 (27.2%) | = 4 (18.7%) | 4 (17.9%) | = 5 (12.5%) | 3 (26.3%) |
| Undershoot | 5 (17.4%) | 5 (18.5%) | = 2 (31.2%) | 5 (16.7%) | = 5 (12.5%) | 5 (15.8%) |
| Overrun | 6 (9.8%) | 6 (14.1%) | 4 (18.7%) | 6 (6.0%) | = 5 (12.5%) | = 6 (6.6%) |
| Ground collision with object/obstacle | 7 (7.0%) | 7 (10.9%) | = 6 (6.2%) | = 9 (2.4%) | = 5 (12.5%) | = 6 (6.6%) |

ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

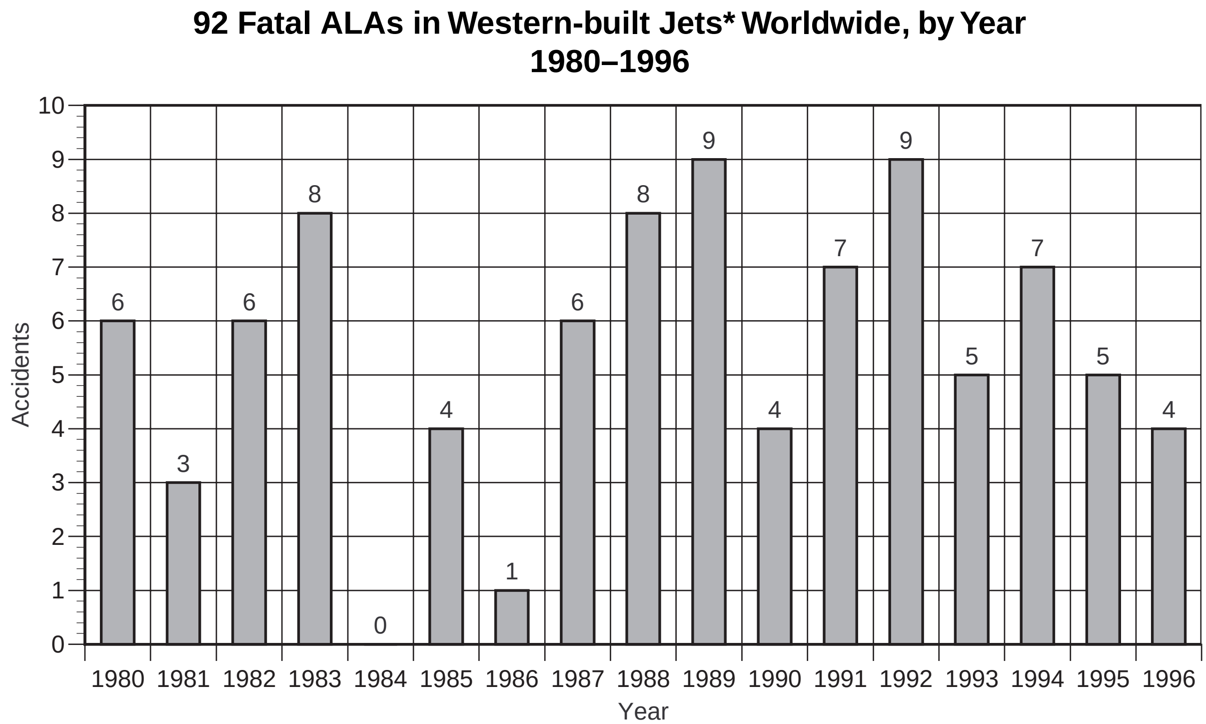
Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Note: The complete list of identified consequences has been shortened for this table. Identified consequences that ranked high in the overall list (first column) sometimes ranked lower for specific types of aircraft. In some instances, two or more identified consequences occurred in equal numbers of accidents, and the identified consequences were assigned equal rankings. For example, some columns may contain two 3s, three 4s, etc. In several instances, a factor shown in the table occurred in equal numbers of accidents with a factor not shown because the factor not shown was not among those ranked 1 through 7 in the “overall ranking” column.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

Africa, South and Central America, and Asia are well above the world average, Africa by a factor of more than five. Australasia, North America and, to a lesser extent, Europe are below the world average. Europe is broken down into the JAA and the other European countries in section 10.7.

Australasia’s excellent record of zero fatal accidents merits further consideration. This is against a background of 5.3 million flights; this can be compared, for example, with the North American sample of 14 fatal accidents in 110.8 million flights. If Australasia had the same underlying accident rate




*Excludes business jets. ALAs – approach-and-landing accidents involving jet aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 3**

as North America, one would expect, on average, one accident every 7.9 million flights; not having had an accident in 5.3 million flights does not necessarily indicate that the Australasian region is any better than North America. Though the record in Australasia is good, one must be very cautious in interpreting this result. (See also 10.5.)

## 10.5 Fatal Accident Rates "Unlikely to Be Exceeded," by Region of Operator

When analyzing a small number of events, the accident rates derived may not be a reliable indication of the true underlying rates. An accepted method in such a situation is to employ the Poisson distribution to determine the maximum fatal accident rates, to a given level of confidence, within which range the underlying rates are likely to fall. For this analysis, this method was applied to determine the accident rate which, to a 95 percent confidence level, is unlikely to be exceeded. This provides pessimistic figures for the accident rates, for which there is only a 5 percent probability that the true underlying rates will exceed.

These rates unlikely to be exceeded are determined by:

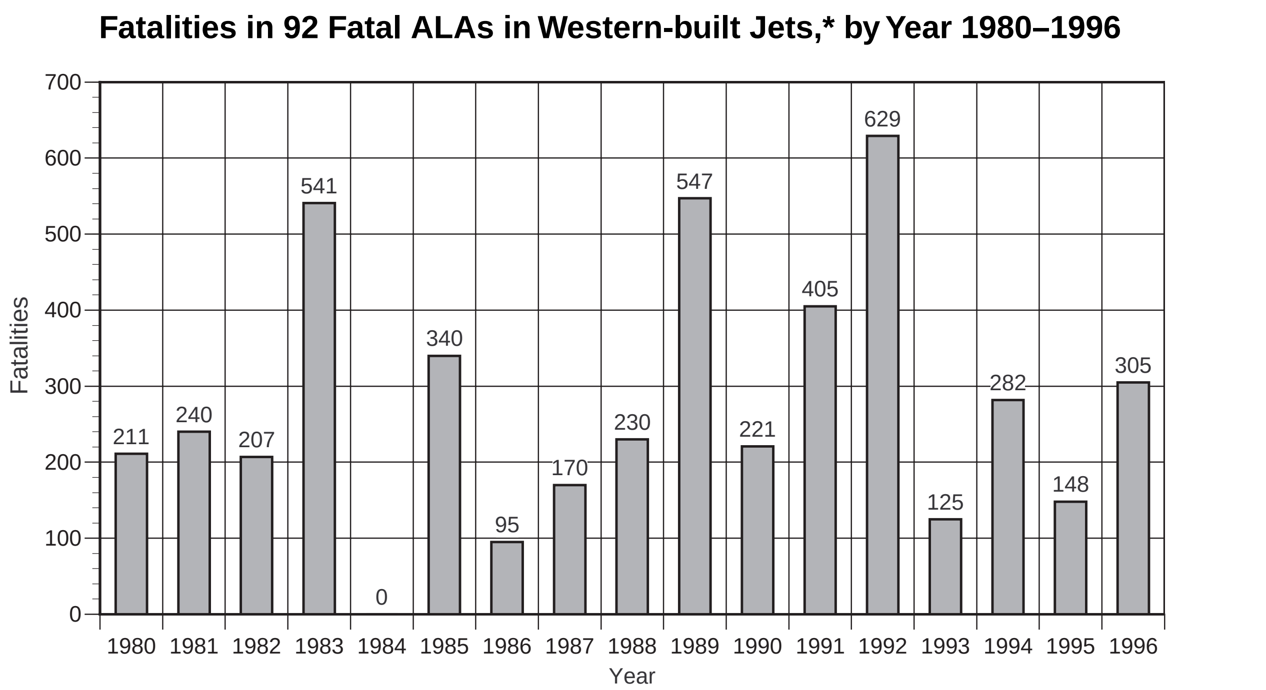
- Considering the number of fatal accidents for each population;
- Determining, using Poisson distribution data, the number of fatal accidents that is unlikely to be exceeded to the defined level of confidence (95 percent); and,
- Dividing this latter figure by the number of flights to obtain a fatal accident rate that is equally unlikely to be exceeded.

The accident rates that the underlying rates are unlikely to exceed are shown in Figure 7 (page 20).

Note that when a 95 percent level of confidence is applied to the fatal accident rates, Australasian operators have a notional accident rate figure, which is unlikely to be exceeded, of 0.57 per million flights rather than the actual rate of zero. This takes into account the relatively few flights accrued by operators in that region.

## 10.6 Fatalities by Region of Operator

The number of fatalities occurring in Western-built jets in ALAs between 1980 and 1996 inclusive was 4,696. The figures are shown by region of operator in Figure 8 (page 21).

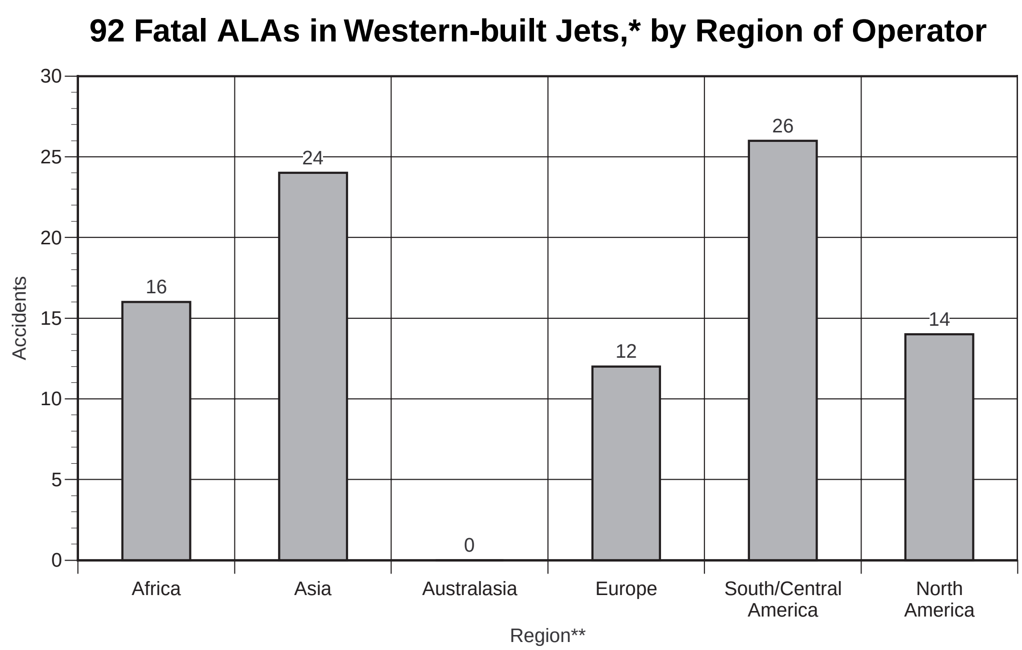



*Excludes business jets. ALAs – approach-and-landing accidents involving jet aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 4**




*Excludes business jets. JAA – Joint Aviation Authorities ALAs – approach-and-landing accidents involving jet aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

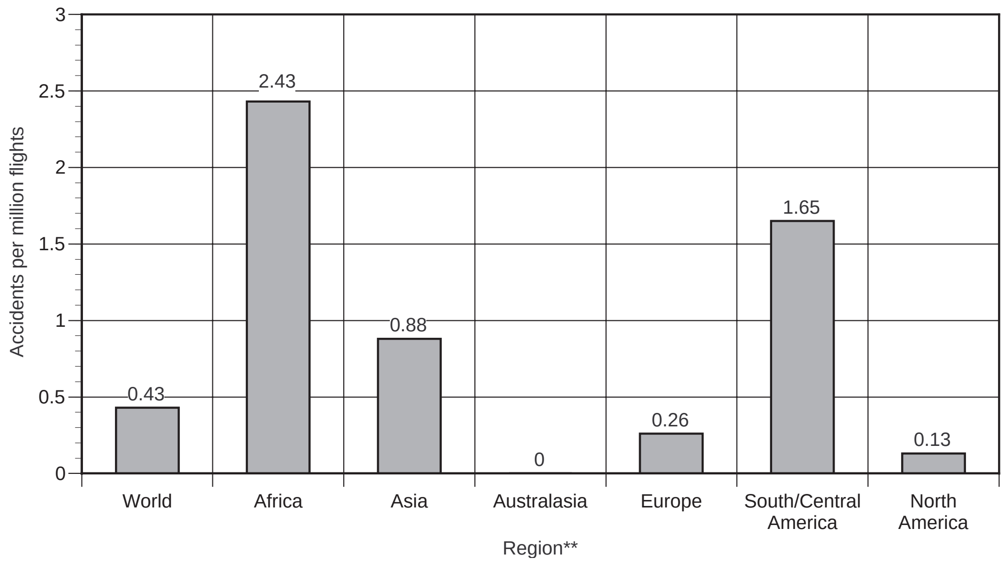
Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

**Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 5**

## 92 Fatal ALAs in Western-built Jets,* Rates by Region of Operator




*Excludes business jets. ALAs – approach-and-landing accidents involving jet aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

**Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 6**

### 10.7 Fatal Accident Rates for the JAA Countries and Other European Countries

As mentioned earlier, Europe is divided into the JAA countries, which use a common set of safety regulations and comprise 19 full-member countries, and the other European countries. Of the 12 fatal ALAs involving European operators (Figure 5, page 17), seven involved JAA operators and five involved operators from the other European countries. The numbers of flights for each group of countries were 42.8 million and 3.04 million respectively. This gives the following fatal accident rates for approach-and-landing accidents:

- JAA full-member countries: 0.164 per million flights; and,
- Other European countries: 1.640 per million flights.

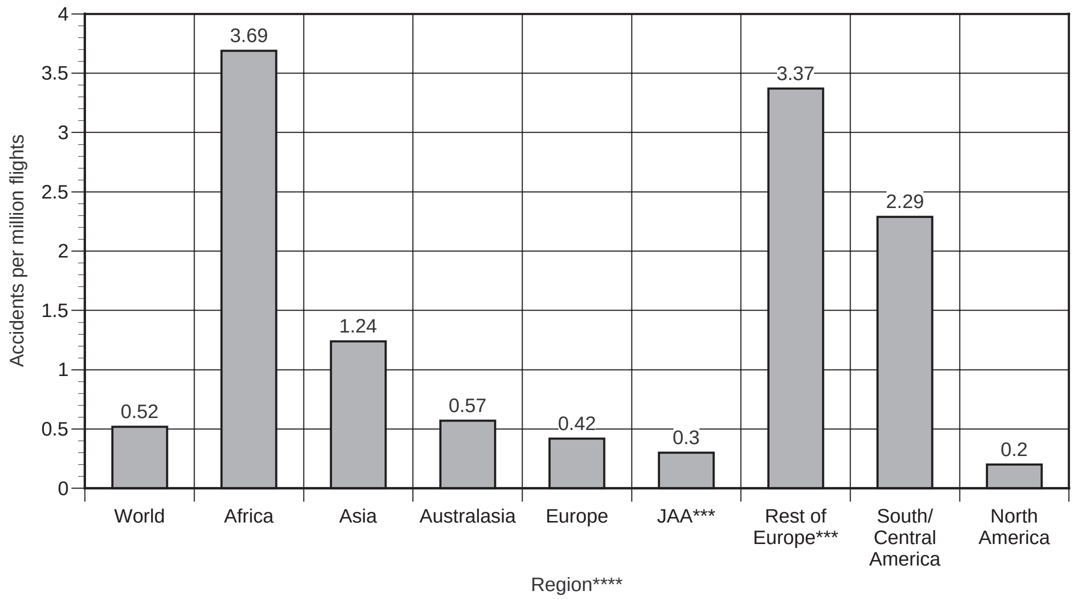
The JAA full-member countries, therefore, have an accident rate 10 times better than the other European countries, and comparable with North America.

## 11.0 Conclusions

An analysis has been carried out to establish the primary causal factors, causal factors, circumstantial factors and consequences of the 287 fatal accidents recorded on the U.K. CAA database for its *Global Fatal Accident Review* that occurred during approach, final approach and landing.[1] This covered all such known accidents to jet and turboprop airplanes having greater than 5,700 kilograms (12,500 pounds) MTOW, including business jets, between 1980 and 1996. It excluded test flights and accidents resulting from terrorism and sabotage; Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were excluded prior to 1990. The following main conclusions were drawn:

1. There was an average of 14.8 fatal accidents during approach and landing per year for non-U.S.S.R./C.I.S. aircraft. There was an increasing trend that, if continued, would result in 23 fatal accidents annually by 2010;
2. The overall number of fatalities to passengers and crew members from all ALAs in the period was 7,185. The non-C.I.S. aircraft can be expected to suffer 495 fatalities annually by 2010 if the overall trend continues;
3. Of the 287 accidents, the majority occurred to aircraft used by operators from North America, South and Central America and Europe; most flights occurred in these regions. Only five accidents involved operators from Australasia;
4. Sixty-two percent of the accidents occurred during passenger operations and 25 percent occurred during freight, ferry and positioning flights when no passengers were carried. These figures cannot reflect the relative number of flights flown for these purposes

**Fatal ALA Rates of Western-built Jets* Unlikely to Be Exceeded****




*Excludes business jets. JAA – Joint Aviation Authorities ALAs – approach-and-landing accidents involving jet aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

**At 95 percent confidence level

***Data for Europe are divided to show rates for the 19 full-member JAA countries and the other European countries.

****Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 7**

and suggest a far higher accident rate on freight, ferry and positioning flights — possibly eight times higher;

5. For accidents where the type of approach was known, 75 percent occurred when a precision approach aid was not available or was not used;

6. Fifty percent of the accidents occurred during daylight, 39 percent occurred during night and 2 percent occurred during twilight. Though the exact proportions of night and day approaches are not known, it seems likely that the accident rate at night is close to three times that for day;

7. Business jets suffered more accidents on night approaches and landings than by day;

8. Fatal accidents to Western-built jets on approach and landing average five per year to six per year, and there is an overall increasing trend during the period of the study. Fatalities average 276 per year and are increasing. The average number of fatalities is 51 per accident, and 61 percent of the aircraft occupants;

9. Most fatal accidents to Western-built jets occurred to operators from South and Central America and Asia. (See 10 below.);

10. The fatal accident rate for Western-built jets was highest for Africa (2.43 per million flights) and South and Central America (1.65 per million flights). Australasia had no fatal accidents to Western-built jets;

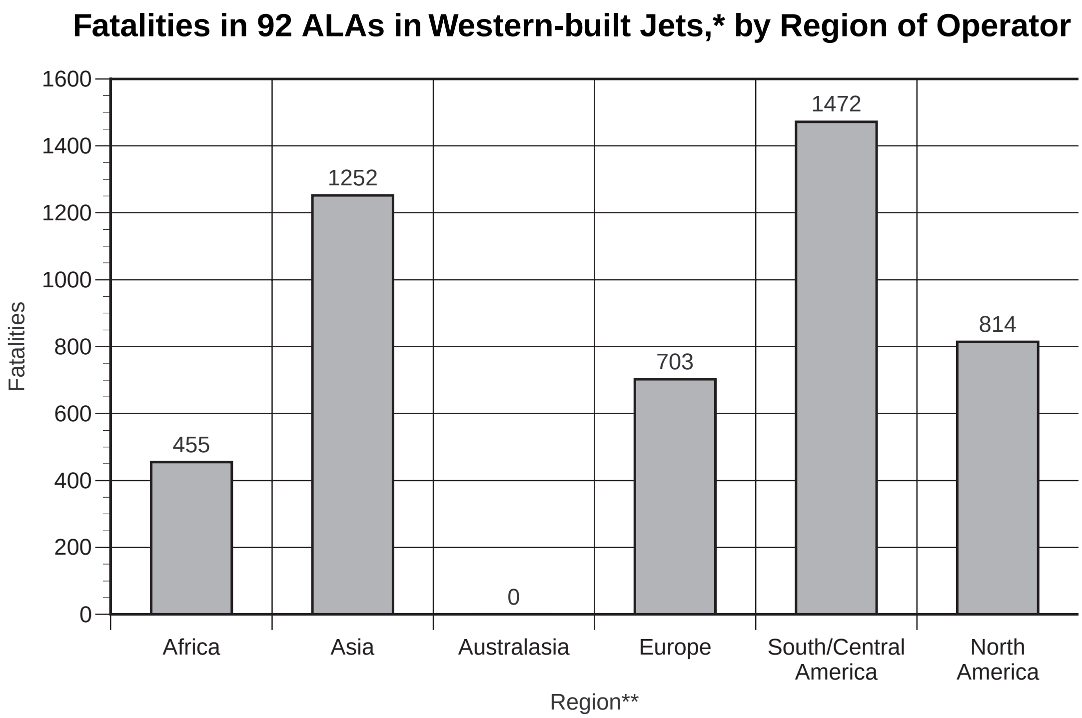
11. When Europe is divided into the 19 full-member JAA countries and the other European countries, JAA countries have an accident rate for Western-built jets (0.16 per million flights) that is 10 times lower than that for the other European countries;

12. The most common primary causal factor was judged to be "omission of action/inappropriate action." This most often referred to the crew continuing the descent below the DH or MDA without visual reference or when visual cues were lost;

13. The second most common primary causal factor, "lack of positional awareness in the air," generally related to CFIT accidents;

14. When all causal factors (primary and contributory) are considered, the most frequent are those referred to above as primary causal factors, plus "slow and/or low on approach," "flight handling" and "poor professional judgment/airmanship";

15. Aircraft built and operated in the U.S.S.R./C.I.S. had "press-on-itis" as the most frequent causal factor, even though this was only sixth in the overall ranking;




*Excludes business jets. ALAs – approach-and-landing accidents involving jet and turboprop aircraft with a maximum takeoff weight greater than 5,700 kilograms (12,500 pounds). U.S.S.R. – Union of Soviet Socialist Republics C.I.S. – Commonwealth of Independent States

Note: Accidents to Eastern-built aircraft and operators from the U.S.S.R./C.I.S. were not included for years before 1990.

**Regions defined by Airclaims and shown in Appendix 2.

Source: U.K. Civil Aviation Authority/Flight Safety Foundation

**Figure 8**

16. The most frequent circumstantial factors were "nonfitment of presently available safety equipment" (generally GPWS) and "failure in CRM." "Lack of ground aids" was cited in at least 25 percent of accidents for all classes of aircraft; and,

17. The most frequent consequences were "collision with terrain/water/obstacle," and "CFIT." These were followed by "loss of control in flight," "postimpact fire" and "undershoot." Eastern-built (U.S.S.R./C.I.S.) jets had fatal overruns as a consequence at nearly twice the frequency of the overall sample.♦

## References

1. U.K. Civil Aviation Authority (CAA). Global Fatal Accident Review, 1980–1996. Report no. CAP 681. March 1998.

2. Airclaims Ltd. World Aircraft Accident Summary, 1980–1996.

3. Ashford, R. Global Airline Safety — The Problem and Possible Solutions. Report no. RA/9703. November 1997.

4. International Air Transport Association (IATA). World Air Transport Statistics — IATA Members' Air Transport Operations.

5. U.K. CAA Economic Regulation Group. "Fixed Wing Air Transport Movements at U.K. Airports" (unpublished note, Dec. 22, 1997).

## Further Reading from FSF Publications

Enders, J.H. et al. "Airport Safety: A Study of Accidents and Available Approach-and-landing Aids." *Flight Safety Digest* Volume 15 (March 1996): 1–36.

Khatwa, R.; Roelen, A.L.C. "An Analysis of Controlled-flight-into-terrain (CFIT) Accidents of Commercial Operators, 1988 through 1994." *Flight Safety Digest* Volume 15 (April–May 1996): 1-45.

Flight Safety Foundation. "Dubrovnik-bound Flight Crew's Improperly Flown Nonprecision Instrument Approach Results in Controlled-flight-into-terrain Accident." *Flight Safety Digest* Volume 15 (July–Aug. 1996): 1–25.

## Appendix 1
## Factors and Consequences Attributed to Fatal Approach-and-landing Accidents

| A | Causal Group | | Causal Factor |
|---|---|---|---|
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability |
| | | 1.2 | System failure — flight deck information |
| | | 1.3 | System failure — other |
| A.2 | Air traffic control/Ground aids | 2.1 | Incorrect or inadequate instruction/advice |
| | | 2.2 | Misunderstood/missed communication |
| | | 2.3 | Failure to provide separation in the air |
| | | 2.4 | Failure to provide separation on the ground |
| | | 2.5 | Ground aid malfunction or unavailable |
| A.3 | Environmental | 3.1 | Structural overload |
| | | 3.2 | Wind shear/upset/turbulence |
| | | 3.3 | Icing |
| | | 3.4 | Wake turbulence — aircraft spacing |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. |
| | | 3.6 | Birds |
| | | 3.7 | Lightning |
| | | 3.8 | Runway condition unknown to crew |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air |
| | | 4.2 | Lack of positional awareness on the ground |
| | | 4.3 | Lack of awareness of circumstances in flight |
| | | 4.4 | Incorrect selection on instrument/navaid |
| | | 4.5 | Action on wrong control/instrument |
| | | 4.6 | Slow/delayed action |
| | | 4.7 | Omission of action/inappropriate action |
| | | 4.8 | "Press-on-itis" |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) |
| | | 4.10 | Poor professional judgment/airmanship |
| | | 4.11 | Disorientation or visual illusion |
| | | 4.12 | Fatigue |
| | | 4.13 | State of mind |
| | | 4.14 | Interaction with automation |
| | | 4.15 | Fast and/or high on approach |
| | | 4.16 | Slow and/or low on approach |
| | | 4.17 | Loading incorrect |
| | | 4.18 | Flight handling |
| | | 4.19 | Lack of qualification/training/experience |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance |
| | | 4.21 | Failure in look-out |
| | | 4.22 | Deliberate nonadherence to procedures |
| A.5 | Engine | 5.1 | Engine failure or malfunction |
| | | 5.2 | Propeller failure |
| | | 5.3 | Damage due to noncontainment |
| | | 5.4 | Fuel contamination |
| | | 5.5 | Engine failure simulated |
| A.6 | Fire | 6.1 | Engine fire or overheat |
| | | 6.2 | Fire due to aircraft systems |
| | | 6.3 | Fire — other cause |
| | | 6.4 | Postimpact fire |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft |
| | | 7.4 | Loading error |
| | | 7.5 | Bogus parts |

## Appendix 1
## Factors and Consequences Attributed to Fatal Approach-and-landing Accidents
*(continued)*

| A | Causal Group | | Causal Factor |
|---|---|---|---|
| A.8 | Structure | 8.1 | Corrosion/fatigue |
| | | 8.2 | Overload failure |
| | | 8.3 | Flutter |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew |
| | | 9.2 | Inadequate airport support |
| A.10 | Design | 10.1 | Design shortcomings |
| | | 10.2 | Unapproved modification |
| | | 10.3 | Manufacturing defect |
| A.11 | Performance | 11.1 | Unable to maintain speed/height |
| | | 11.2 | Aircraft becomes uncontrollable |
| A.12 | Other | 12.1 | Caused by other aircraft |
| | | 12.2 | Nonadherence to cabin safety procedures |

| B | Circumstantial Group | | Circumstantial Factor |
|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground-proximity warning system, traffic-alert and collision avoidance system, wind-shear warning, etc.) |
| | | 1.2 | Failure/inadequacy of safety equipment |
| B.2 | Air traffic control/Ground aids | 2.1 | Lack of air traffic control |
| | | 2.2 | Lack of ground aids |
| B.3 | Environmental | 3.1 | Poor visibility |
| | | 3.2 | Weather |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) |
| B.4 | Crew | 4.1 | Training inadequate |
| | | 4.2 | Presented with situation beyond training |
| | | 4.3 | Failure in crew resource management (cross-check/coordinate) |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures |
| | | 5.2 | Company management failure |
| | | 5.3 | Inadequate regulation |
| | | 5.4 | Inadequate regulatory oversight |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight |

| C | Consequence |
|---|---|
| C.1 | Controlled flight into terrain (CFIT) |
| C.2 | Collision with terrain/water/obstacle |
| C.3 | Midair collision |
| C.4 | Ground collision with other aircraft |
| C.5 | Ground collision with object/obstacle |
| C.6 | Loss of control in flight |
| C.7 | Fuel exhaustion |
| C.8 | Overrun |
| C.9 | Undershoot |
| C.10 | Structural failure |
| C.11 | Postimpact fire |
| C.12 | Fire/smoke during operation |
| C.13 | Emergency evacuation difficulties |
| C.14 | Forced landing — land or water |
| C.15 | Other cause of fatality |

**Level of confidence*** ☐ **High** ☐ **Medium** ☐ **Low** ☐ **Insufficient information**

* The AAG recorded the level of confidence for each accident to reflect the group's confidence in its analysis as a whole, not for individual factors and circumstances.

## Appendix 2
## Regions* and Countries

### Africa

Algeria
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde Islands
Central African Republic
Chad
Ciskei
Comoros
Congo
Democratic Republic of Congo
Djibouti
Egypt
Ethiopia
Gabon
Gambia
Ghana
Guinea
Guinea-Bissau
Ivory Coast
Kenya
Lesotho
Liberia
Libya
Madagascar
Malawi
Mali
Mauritania
Mauritius
Morocco
Mozambique
Namibia
Niger
Nigeria
Republic of Bophuthatswana
Rwanda
Sao Tome and Principe
Senegal
Seychelles
Sierra Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Tunisia
Uganda
Zambia
Zimbabwe

### Asia

Afghanistan
Bahrain
Bangladesh
Bhutan
Brunei
Cambodia
China
Hong Kong
India
Indonesia
Iran
Iraq
Israel
Japan
Jordan
Korea
Kuwait
Laos
Lebanon
Macau
Malaysia
Maldives
Mongolia
Myanmar
Nepal
Oman
Pakistan
Palestine
Philippines
Qatar
Saudi Arabia
Singapore
Sri Lanka
Syria
Taiwan
Thailand
Vietnam
Yemen

### Australasia

American Samoa
Australia
Cook Islands
Fiji
French Polynesia
Guam
Kiribati
Marshall Islands
Nauru
New Caledonia
New Zealand
Northern Marianas Islands
Pacific Islands
Palau
Papua New Guinea
Solomon Islands
Tonga
Vanuatu
Western Samoa

### Europe

JAA full-member countries in **bold** and C.I.S. countries in *italic*:

Albania
*Armenia*
**Austria**
*Azerbaijan*
*Belarus*
**Belgium**
Bosnia-Herzegovina
Bulgaria
Croatia
Cyprus
Czechoslovakia
Czech Republic
**Denmark**
Estonia
Faroe Islands
**Finland**
**France**
*Georgia*
**Germany**
Gibraltar
**Greece**
Greenland
Hungary
**Iceland**
**Ireland**
**Italy**
*Kazakstan*
*Kyrgyzstan*
Latvia
Lichtenstein
Lithuania
**Luxembourg**
Macedonia
Malta
*Moldova*
**Monaco**
Montenegro
**Netherlands**
**Norway**
Poland
**Portugal**
Romania

## Appendix 2
## Regions and Countries *(continued)*

*Russia*
Serbia
Slovakia
Slovenia
**Spain**
**Sweden**
**Switzerland**
*Tajikistan*
Turkey
*Turkmenistan*
*Ukraine*
**United Kingdom**
U.S.S.R.
*Uzbekistan*
Yugoslavia

### North America

Anguilla
Antigua & Barbuda
Aruba
Bahamas
Barbados
Bermuda
Canada
Cayman Islands
Cuba
Dominica
Dominican Republic
Grenada
Guadeloupe
Haiti
Jamaica
Martinique
Montserrat
Puerto Rico
St. Kitts & Nevis
St. Lucia
St. Pierre & Miquelon
Trinidad & Tobago
St. Vincent & the Grenadines
Turks & Caicos Islands
United States
Virgin Islands (U.S. and British)

### South/Central America

Argentina
Belize
Bolivia
Brazil
Chile
Colombia
Costa Rica
Ecuador
El Salvador
Falkland Islands
French Guyana
Guatemala
Guyana
Honduras
Mexico
Nicaragua
Panama
Paraguay
Peru
Suriname
Uruguay
Venezuela

*Regions defined by Airclaims

## Appendix 3
## Joint Aviation Authorities Full-member Countries

- Austria
- Belgium
- Denmark
- Finland
- France
- Germany
- Greece
- Iceland
- Ireland
- Italy
- Luxembourg
- Monaco
- Netherlands
- Norway
- Portugal
- Spain
- Sweden
- Switzerland
- United Kingdom

## Appendix 4.1
## Factors and Consequences Attributed to 92 Fatal Approach-and-landing Accidents in Western-built Jets*

| | | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| **A** | **Causal Factor** | | | **Primary** | **Causal** | **Total** |
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability | 2 | 7 | 9 |
| | | 1.2 | System failure — flight deck information | 1 | 2 | 3 |
| | | 1.3 | System failure — other | 0 | 4 | 4 |
| A.2 | Air traffic control/Ground aids | 2.1 | Incorrect or inadequate instruction/advice | 1 | 9 | 10 |
| | | 2.2 | Misunderstood/missed communication | 0 | 4 | 4 |
| | | 2.3 | Failure to provide separation in the air | 0 | 2 | 2 |
| | | 2.4 | Failure to provide separation on the ground | 1 | 1 | 2 |
| | | 2.5 | Ground aid malfunction or unavailable | 0 | 2 | 2 |
| A.3 | Environmental | 3.1 | Structural overload | 0 | 0 | 0 |
| | | 3.2 | Wind shear/upset/turbulence | 2 | 8 | 10 |
| | | 3.3 | Icing | 0 | 0 | 0 |
| | | 3.4 | Wake turbulence — aircraft spacing | 0 | 0 | 0 |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. | 0 | 2 | 2 |
| | | 3.6 | Birds | 0 | 0 | 0 |
| | | 3.7 | Lightning | 0 | 0 | 0 |
| | | 3.8 | Runway condition unknown to crew | 1 | 3 | 4 |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air | 15 | 25 | 40 |
| | | 4.2 | Lack of positional awareness on the ground | 0 | 0 | 0 |
| | | 4.3 | Lack of awareness of circumstances in flight | 0 | 1 | 1 |
| | | 4.4 | Incorrect selection on instrument/navaid | 0 | 2 | 2 |
| | | 4.5 | Action on wrong control/instrument | 0 | 1 | 1 |
| | | 4.6 | Slow/delayed action | 2 | 9 | 11 |
| | | 4.7 | Omission of action/inappropriate action | 25 | 15 | 40 |
| | | 4.8 | “Press-on-itis” | 9 | 7 | 16 |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) | 1 | 14 | 15 |
| | | 4.10 | Poor professional judgment/airmanship | 5 | 23 | 28 |
| | | 4.11 | Disorientation or visual illusion | 0 | 3 | 3 |
| | | 4.12 | Fatigue | 0 | 3 | 3 |
| | | 4.13 | State of mind | 1 | 0 | 1 |
| | | 4.14 | Interaction with automation | 2 | 5 | 7 |
| | | 4.15 | Fast and/or high on approach | 0 | 9 | 9 |
| | | 4.16 | Slow and/or low on approach | 0 | 32 | 32 |

* Excluding business jets

## Appendix 4.1
## Factors and Consequences Attributed to 92 Fatal Approach-and-landing Accidents in Western-built Jets* *(continued)*

| | | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| A | Causal Factor | | | Primary | Causal | Total |
| | | 4.17 | Loading incorrect | 0 | 0 | 0 |
| | | 4.18 | Flight handling | 9 | 16 | 25 |
| | | 4.19 | Lack of qualification/training/experience | 0 | 6 | 6 |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance | 0 | 1 | 1 |
| | | 4.21 | Failure in look-out | 0 | 2 | 2 |
| | | 4.22 | Deliberate nonadherence to procedures | 2 | 4 | 6 |
| A.5 | Engine | 5.1 | Engine failure or malfunction | 0 | 4 | 4 |
| | | 5.2 | Propeller failure | 0 | 0 | 0 |
| | | 5.3 | Damage due to noncontainment | 0 | 1 | 1 |
| | | 5.4 | Fuel contamination | 0 | 0 | 0 |
| | | 5.5 | Engine failure simulated | 0 | 0 | 0 |
| A.6 | Fire | 6.1 | Engine fire or overheat | 1 | 0 | 1 |
| | | 6.2 | Fire due to aircraft systems | 1 | 0 | 1 |
| | | 6.3 | Fire — other cause | 3 | 0 | 3 |
| | | 6.4 | Postimpact fire | 0 | 13 | 13 |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance | 0 | 0 | 0 |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy | 2 | 0 | 2 |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft | 0 | 0 | 0 |
| | | 7.4 | Loading error | 0 | 0 | 0 |
| | | 7.5 | Bogus parts | 0 | 0 | 0 |
| A.8 | Structure | 8.1 | Corrosion/fatigue | 2 | 1 | 3 |
| | | 8.2 | Overload failure | 0 | 7 | 7 |
| | | 8.3 | Flutter | 0 | 0 | 0 |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew | 0 | 7 | 7 |
| | | 9.2 | Inadequate airport support | 1 | 3 | 4 |
| A.10 | Design | 10.1 | Design shortcomings | 1 | 12 | 13 |
| | | 10.2 | Unapproved modification | 0 | 0 | 0 |
| | | 10.3 | Manufacturing defect | 0 | 1 | 1 |
| A.11 | Performance | 11.1 | Unable to maintain speed/height | 0 | 4 | 4 |
| | | 11.2 | Aircraft becomes uncontrollable | 0 | 8 | 8 |
| A.12 | Other | 12.1 | Caused by other aircraft | 1 | 0 | 1 |
| | | 12.2 | Nonadherence to cabin safety procedures | 0 | 0 | 0 |

* Excluding business jets

## Appendix 4.1
## Factors and Consequences Attributed to 92 Fatal Approach-and-landing Accidents in Western-built Jets* *(continued)*

| B | Circumstantial Factor | | | Number of Times Cited in Accidents |
|---|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground-proximity warning system, traffic-alert and collision avoidance system, wind-shear warning, etc.) | 40 |
| | | 1.2 | Failure/inadequacy of safety equipment | 2 |
| B.2 | Air traffic control/Ground aids | 2.1 | Lack of air traffic control | 2 |
| | | 2.2 | Lack of ground aids | 23 |
| B.3 | Environmental | 3.1 | Poor visibility | 29 |
| | | 3.2 | Weather | 26 |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) | 7 |
| B.4 | Crew | 4.1 | Training inadequate | 7 |
| | | 4.2 | Presented with situation beyond training | 9 |
| | | 4.3 | Failure in crew resource management (cross-check/coordinate) | 38 |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures | 13 |
| | | 5.2 | Company management failure | 18 |
| | | 5.3 | Inadequate regulation | 8 |
| | | 5.4 | Inadequate regulatory oversight | 23 |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight | 0 |

| C | Consequence | Number of Times Cited in Accidents |
|---|---|---|
| C.1 | Controlled flight into terrain (CFIT) | 32 |
| C.2 | Collision with terrain/water/obstacle | 45 |
| C.3 | Midair collision | 1 |
| C.4 | Ground collision with other aircraft | 1 |
| C.5 | Ground collision with object/obstacle | 10 |
| C.6 | Loss of control in flight | 21 |
| C.7 | Fuel exhaustion | 5 |
| C.8 | Overrun | 13 |
| C.9 | Undershoot | 17 |
| C.10 | Structural failure | 2 |
| C.11 | Postimpact fire | 25 |
| C.12 | Fire/smoke during operation | 4 |
| C.13 | Emergency evacuation difficulties | 4 |
| C.14 | Forced landing — land or water | 3 |
| C.15 | Other cause of fatality | 0 |

* Except business jets

**Level of confidence** **49 High** **36 Medium** **6 Low** **1 Insufficient information**

## Appendix 4.2
## Factors and Consequences Attributed to 16 Fatal Approach-and-landing Accidents in Eastern-built Jets

| A | Causal Factor | | | Number of Times Cited in Accidents: Primary | Causal | Total |
|---|---|---|---|---|---|---|
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability | 0 | 0 | 0 |
| | | 1.2 | System failure — flight deck information | 1 | 1 | 2 |
| | | 1.3 | System failure — other | 0 | 1 | 1 |
| A.2 | Air traffic control/Ground aids | 2.1 | Incorrect or inadequate instruction/advice | 0 | 0 | 0 |
| | | 2.2 | Misunderstood/missed communication | 0 | 0 | 0 |
| | | 2.3 | Failure to provide separation in the air | 0 | 0 | 0 |
| | | 2.4 | Failure to provide separation in the ground | 0 | 0 | 0 |
| | | 2.5 | Ground aid malfunction or unavailable | 0 | 0 | 0 |
| A.3 | Environmental | 3.1 | Structural overload | 0 | 0 | 0 |
| | | 3.2 | Wind shear/upset/turbulence | 1 | 0 | 1 |
| | | 3.3 | Icing | 0 | 0 | 0 |
| | | 3.4 | Wake turbulence — aircraft spacing | 0 | 0 | 0 |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. | 0 | 0 | 0 |
| | | 3.6 | Birds | 0 | 0 | 0 |
| | | 3.7 | Lightning | 0 | 0 | 0 |
| | | 3.8 | Runway condition unknown to crew | 0 | 0 | 0 |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air | 4 | 3 | 7 |
| | | 4.2 | Lack of positional awareness on the ground | 0 | 0 | 0 |
| | | 4.3 | Lack of awareness of circumstances in flight | 0 | 0 | 0 |
| | | 4.4 | Incorrect selection on instrument/navaid | 0 | 0 | 0 |
| | | 4.5 | Action on wrong control/instrument | 0 | 0 | 0 |
| | | 4.6 | Slow/delayed action | 0 | 1 | 1 |
| | | 4.7 | Omission of action/inappropriate action | 4 | 2 | 6 |
| | | 4.8 | “Press-on-itis“ | 5 | 2 | 7 |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) | 0 | 3 | 3 |
| | | 4.10 | Poor professional judgment/airmanship | 0 | 2 | 2 |
| | | 4.11 | Disorientation or visual illusion | 0 | 0 | 0 |
| | | 4.12 | Fatigue | 0 | 1 | 1 |
| | | 4.13 | State of mind | 0 | 0 | 0 |
| | | 4.14 | Interaction with automation | 0 | 0 | 0 |
| | | 4.15 | Fast and/or high on approach | 0 | 4 | 4 |
| | | 4.16 | Slow and/or low on approach | 0 | 5 | 5 |

## Appendix 4.2

## Factors and Consequences Attributed to 16 Fatal Approach-and-landing Accidents in Eastern-built Jets *(continued)*

| A | Causal Factor | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| | | | | Primary | Causal | Total |
| | | 4.17 | Loading incorrect | 0 | 0 | 0 |
| | | 4.18 | Flight handling | 1 | 2 | 3 |
| | | 4.19 | Lack of qualification/training/experience | 0 | 0 | 0 |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance | 0 | 0 | 0 |
| | | 4.21 | Failure in look-out | 0 | 0 | 0 |
| | | 4.22 | Deliberate nonadherence to procedures | 0 | 3 | 3 |
| A.5 | Engine | 5.1 | Engine failure or malfunction | 0 | 0 | 0 |
| | | 5.2 | Propeller failure | 0 | 0 | 0 |
| | | 5.3 | Damage due to noncontainment | 0 | 0 | 0 |
| | | 5.4 | Fuel contamination | 0 | 0 | 0 |
| | | 5.5 | Engine failure simulated | 0 | 0 | 0 |
| A.6 | Fire | 6.1 | Engine fire or overheat | 0 | 0 | 0 |
| | | 6.2 | Fire due to aircraft systems | 0 | 1 | 1 |
| | | 6.3 | Fire — other cause | 0 | 0 | 0 |
| | | 6.4 | Postimpact fire | 0 | 2 | 2 |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance | 0 | 0 | 0 |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy | 0 | 0 | 0 |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft | 0 | 0 | 0 |
| | | 7.4 | Loading error | 0 | 0 | 0 |
| | | 7.5 | Bogus parts | 0 | 0 | 0 |
| A.8 | Structure | 8.1 | Corrosion/fatigue | 0 | 0 | 0 |
| | | 8.2 | Overload failure | 0 | 1 | 1 |
| | | 8.3 | Flutter | 0 | 0 | 0 |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew | 0 | 1 | 1 |
| | | 9.2 | Inadequate airport support | 0 | 2 | 2 |
| A.10 | Design | 10.1 | Design shortcomings | 0 | 2 | 2 |
| | | 10.2 | Unapproved modification | 0 | 0 | 0 |
| | | 10.3 | Manufacturing defect | 0 | 0 | 0 |
| A.11 | Performance | 11.1 | Unable to maintain speed/height | 0 | 0 | 0 |
| | | 11.2 | Aircraft becomes uncontrollable | 0 | 0 | 0 |
| A.12 | Other | 12.1 | Caused by other aircraft | 0 | 0 | 0 |
| | | 12.2 | Nonadherence to cabin safety procedures | 0 | 0 | 0 |

## Appendix 4.2
## Factors and Consequences Attributed to 16 Fatal Approach-and-landing Accidents In Eastern-built Jets *(continued)*

| B | Circumstantial Factor | | | Number of Times Cited in Accidents |
|---|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground proximity warning (system, traffic-alert and collision avoidance system, wind-shear warning, etc.) | 8 |
| | | 1.2 | Failure/inadequacy of safety equipment | 0 |
| B.2 | ATC/Ground aids | 2.1 | Lack of air traffic control | 0 |
| | | 2.2 | Lack of ground aids | 5 |
| B.3 | Environmental | 3.1 | Poor visibility | 4 |
| | | 3.2 | Weather | 7 |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) | 1 |
| B.4 | Crew | 4.1 | Training inadequate | 1 |
| | | 4.2 | Presented with situation beyond training | 0 |
| | | 4.3 | Failure in crew resource management (cross-check/coordinate) | 8 |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures | 1 |
| | | 5.2 | Company management failure | 3 |
| | | 5.3 | Inadequate regulation | 1 |
| | | 5.4 | Inadequate regulatory oversight | 4 |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight | 0 |

| C | Consequence | Number of Times Cited in Accidents |
|---|---|---|
| C.1 | Controlled flight into terrain (CFIT) | 9 |
| C.2 | Collision with terrain/water/obstacle | 5 |
| C.3 | Midair collision | 0 |
| C.4 | Ground collision with other aircraft | 1 |
| C.5 | Ground collision with object/obstacle | 1 |
| C.6 | Loss of control in flight | 1 |
| C.7 | Fuel exhaustion | 0 |
| C.7 | Overrun | 3 |
| C.9 | Undershoot | 5 |
| C.10 | Structural failure | 0 |
| C.11 | Postimpact fire | 3 |
| C.12 | Fire/smoke during operation | 1 |
| C.13 | Emergency evacuation difficulties | 0 |
| C.14 | Forced landing — land or water | 0 |
| C.15 | Other cause of fatality | 0 |

**Level of confidence** **9 High** **5 Medium** **2 Low** **0 Insufficient information**

## Appendix 4.3
## Factors and Consequences Attributed to 84 Fatal Approach-and-landing Accidents in Western-built Turboprops

| A | Causal Factor | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| | | | | Primary | Causal | Total |
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability | 1 | 2 | 3 |
| | | 1.2 | System failure — flight deck information | 1 | 5 | 6 |
| | | 1.3 | System failure — other | 0 | 4 | 4 |
| A.2 | ATC/Ground aids | 2.1 | Incorrect or inadequate instruction/advice | 0 | 4 | 4 |
| | | 2.2 | Misunderstood/missed communication | 0 | 1 | 1 |
| | | 2.3 | Failure to provide separation in the air | 0 | 1 | 1 |
| | | 2.4 | Failure to provide separation on the ground | 0 | 1 | 1 |
| | | 2.5 | Ground aid malfunction or unavailable | 0 | 2 | 2 |
| A.3 | Environmental | 3.1 | Structural overload | 0 | 0 | 0 |
| | | 3.2 | Wind shear/upset/turbulence | 3 | 5 | 8 |
| | | 3.3 | Icing | 1 | 3 | 4 |
| | | 3.4 | Wake turbulence — aircraft spacing | 0 | 0 | 0 |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. | 0 | 2 | 2 |
| | | 3.6 | Birds | 0 | 0 | 0 |
| | | 3.7 | Lightning | 1 | 0 | 1 |
| | | 3.8 | Runway condition unknown to crew | 0 | 1 | 1 |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air | 16 | 19 | 35 |
| | | 4.2 | Lack of positional awareness the on ground | 0 | 0 | 0 |
| | | 4.3 | Lack of awareness of circumstances in flight | 0 | 1 | 1 |
| | | 4.4 | Incorrect selection on instrument/navaid | 1 | 0 | 1 |
| | | 4.5 | Action on wrong control/instrument | 0 | 0 | 0 |
| | | 4.6 | Slow/delayed action | 0 | 3 | 3 |
| | | 4.7 | Omission of action/inappropriate action | 14 | 22 | 36 |
| | | 4.8 | "Press-on-itis" | 7 | 10 | 17 |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) | 4 | 14 | 18 |
| | | 4.10 | Poor professional judgment/airmanship | 3 | 13 | 16 |
| | | 4.11 | Disorientation or visual illusion | 1 | 1 | 2 |
| | | 4.12 | Fatigue | 0 | 0 | 0 |
| | | 4.13 | State of mind | 0 | 1 | 1 |
| | | 4.14 | Interaction with automation | 0 | 0 | 0 |
| | | 4.15 | Fast and/or high on approach | 0 | 8 | 8 |
| | | 4.16 | Slow and/or low on approach | 0 | 32 | 32 |

## Appendix 4.3
## Factors and Consequences Attributed to 84 Fatal Approach-and-landing Accidents in Western-built Turboprops *(continued)*

| A | Causal Factor | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| | | | | Primary | Causal | Total |
| | | 4.17 | Loading incorrect | 1 | 2 | 3 |
| | | 4.18 | Flight handling | 16 | 17 | 33 |
| | | 4.19 | Lack of qualification/training/experience | 0 | 6 | 6 |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance | 0 | 2 | 2 |
| | | 4.21 | Failure in look-out | 1 | 2 | 3 |
| | | 4.22 | Deliberate nonadherence to procedures | 2 | 7 | 9 |
| A.5 | Engine | 5.1 | Engine failure or malfunction | 0 | 5 | 5 |
| | | 5.2 | Propeller failure | 1 | 0 | 1 |
| | | 5.3 | Damage due to noncontainment | 2 | 0 | 2 |
| | | 5.4 | Fuel contamination | 0 | 0 | 0 |
| | | 5.5 | Engine failure simulated | 0 | 1 | 1 |
| A.6 | Fire | 6.1 | Engine fire or overheat | 0 | 1 | 1 |
| | | 6.2 | Fire due to aircraft systems | 0 | 0 | 0 |
| | | 6.3 | Fire — other cause | 1 | 0 | 1 |
| | | 6.4 | Postimpact fire | 0 | 11 | 11 |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance | 0 | 0 | 0 |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy | 1 | 4 | 5 |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft | 0 | 0 | 0 |
| | | 7.4 | Loading error | 1 | 2 | 3 |
| | | 7.5 | Bogus parts | 0 | 0 | 0 |
| A.8 | Structure | 8.1 | Corrosion/fatigue | 1 | 1 | 2 |
| | | 8.2 | Overload failure | 0 | 3 | 3 |
| | | 8.3 | Flutter | 0 | 1 | 1 |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew | 0 | 2 | 2 |
| | | 9.2 | Inadequate airport support | 0 | 4 | 4 |
| A.10 | Design | 10.1 | Design shortcomings | 2 | 9 | 11 |
| | | 10.2 | Unapproved modification | 0 | 0 | 0 |
| | | 10.3 | Manufacturing defect | 0 | 0 | 0 |
| A.11 | Performance | 11.1 | Unable to maintain speed/height | 0 | 4 | 4 |
| | | 11.2 | Aircraft becomes uncontrollable | 0 | 3 | 3 |
| A.12 | Other | 12.1 | Caused by other aircraft | 0 | 0 | 0 |
| | | 12.2 | Nonadherence to cabin safety procedures | 0 | 0 | 0 |

## Appendix 4.3
## Factors and Consequences Attributed to 84 Fatal Approach-and-landing Accidents in Western-built Turboprops *(continued)*

| B | Circumstantial Factor | | | Number of Times Cited in Accidents |
|---|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground-proximity warning system, traffic-alert and collision avoidance system, wind-shear warning, etc.) | 38 |
| | | 1.2 | Failure/inadequacy of safety equipment | 3 |
| B.2 | Air traffic control/Ground aids | 2.1 | Lack of air traffic control | 1 |
| | | 2.2 | Lack of ground aids | 22 |
| B.3 | Environmental | 3.1 | Poor visibility | 25 |
| | | 3.2 | Weather | 41 |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) | 3 |
| B.4 | Crew | 4.1 | Training inadequate | 7 |
| | | 4.2 | Presented with situation beyond training | 1 |
| | | 4.3 | Failure in crew resource management (cross-check/coordinate) | 37 |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures | 7 |
| | | 5.2 | Company management failure | 21 |
| | | 5.3 | Inadequate regulation | 8 |
| | | 5.4 | Inadequate regulatory oversight | 22 |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight | 0 |

| C | Consequence | Number of Times Cited in Accidents |
|---|---|---|
| C.1 | Controlled flight into terrain (CFIT) | 34 |
| C.2 | Collision with terrain/water/obstacle | 42 |
| C.3 | Midair collision | 1 |
| C.4 | Ground collision with other aircraft | 2 |
| C.5 | Ground collision with object/obstacle | 2 |
| C.6 | Loss of control in flight | 32 |
| C.7 | Fuel exhaustion | 0 |
| C.8 | Overrun | 5 |
| C.9 | Undershoot | 14 |
| C.10 | Structural failure | 3 |
| C.11 | Postimpact fire | 15 |
| C.12 | Fire/smoke during operation | 2 |
| C.13 | Emergency evacuation difficulties | 4 |
| C.14 | Forced landing — land or water | 2 |
| C.15 | Other cause of fatality | 1 |

**Level of confidence** **51 High** **27 Medium** **4 Low** **2 Insufficient information**

## Appendix 4.4
## Factors and Consequences Attributed to 19 Fatal Approach-and-landing Accidents in Eastern-built Turboprops

| | | | | Number of Total Cited in Accidents | | |
|---|---|---|---|---|---|---|
| A | Causal Factor | | | Primary | Causal | Total |
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability | 0 | 0 | 0 |
| | | 1.2 | System failure — flight deck information | 0 | 0 | 0 |
| | | 1.3 | System failure — other | 0 | 0 | 0 |
| A.2 | Air traffic control/Ground Aids | 2.1 | Incorrect or inadequate instruction/advice | 0 | 0 | 0 |
| | | 2.2 | Misunderstood/missed communication | 0 | 0 | 0 |
| | | 2.3 | Failure to provide separation in the air | 0 | 0 | 0 |
| | | 2.4 | Failure to provide separation on the ground | 0 | 0 | 0 |
| | | 2.5 | Ground aid malfunction or unavailable | 0 | 0 | 0 |
| A.3 | Environmental | 3.1 | Structural overload | 0 | 0 | 0 |
| | | 3.2 | Wind shear/upset/turbulence | 0 | 0 | 0 |
| | | 3.3 | Icing | 1 | 2 | 3 |
| | | 3.4 | Wake turbulence — aircraft spacing | 0 | 0 | 0 |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. | 0 | 3 | 3 |
| | | 3.6 | Birds | 0 | 0 | 0 |
| | | 3.7 | Lightning | 0 | 0 | 0 |
| | | 3.8 | Runway condition unknown to crew | 0 | 0 | 0 |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air | 2 | 4 | 6 |
| | | 4.2 | Lack of positional awareness the on ground | 0 | 0 | 0 |
| | | 4.3 | Lack of awareness of circumstances in flight | 0 | 0 | 0 |
| | | 4.4 | Incorrect selection on instrument/navaid | 0 | 0 | 0 |
| | | 4.5 | Action on wrong control/instrument | 0 | 0 | 0 |
| | | 4.6 | Slow/delayed action | 0 | 1 | 1 |
| | | 4.7 | Omission of action/inappropriate action | 3 | 2 | 5 |
| | | 4.8 | “Press-on-itis” | 6 | 2 | 8 |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) | 0 | 0 | 0 |
| | | 4.10 | Poor professional judgment/airmanship | 0 | 3 | 3 |
| | | 4.11 | Disorientation or visual illusion | 0 | 0 | 0 |
| | | 4.12 | Fatigue | 0 | 0 | 0 |
| | | 4.13 | State of mind | 0 | 0 | 0 |
| | | 4.14 | Interaction with automation | 0 | 0 | 0 |
| | | 4.15 | Fast and/or high on approach | 0 | 0 | 0 |
| | | 4.16 | Slow and/or low on approach | 0 | 5 | 5 |

## Appendix 4.4
## Factors and Consequences Attributed to 19 Fatal Approach-and-landing Accidents in Eastern-built Turboprops *(continued)*

| A | Causal Factor | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| | | | | Primary | Causal | Total |
| | | 4.17 | Loading incorrect | 0 | 0 | 0 |
| | | 4.18 | Flight handling | 1 | 3 | 4 |
| | | 4.19 | Lack of qualification/training/experience | 0 | 0 | 0 |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance | 0 | 0 | 0 |
| | | 4.21 | Failure in look-out | 0 | 0 | 0 |
| | | 4.22 | Deliberate nonadherence to procedures | 1 | 3 | 4 |
| A.5 | Engine | 5.1 | Engine failure or malfunction | 0 | 0 | 0 |
| | | 5.2 | Propeller failure | 0 | 0 | 0 |
| | | 5.3 | Damage due to noncontainment | 0 | 0 | 0 |
| | | 5.4 | Fuel contamination | 0 | 0 | 0 |
| | | 5.5 | Engine failure simulated | 0 | 0 | 0 |
| A.6 | Fire | 6.1 | Engine fire or overheat | 0 | 0 | 0 |
| | | 6.2 | Fire due to aircraft systems | 0 | 0 | 0 |
| | | 6.3 | Fire — other cause | 0 | 0 | 0 |
| | | 6.4 | Postimpact fire | 0 | 2 | 2 |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance | 0 | 0 | 0 |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy | 0 | 0 | 0 |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft | 0 | 0 | 0 |
| | | 7.4 | Loading error | 1 | 0 | 1 |
| | | 7.5 | Bogus parts | 0 | 0 | 0 |
| A.8 | Structure | 8.1 | Corrosion/fatigue | 0 | 0 | 0 |
| | | 8.2 | Overload failure | 0 | 0 | 0 |
| | | 8.3 | Flutter | 0 | 0 | 0 |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew | 1 | 1 | 2 |
| | | 9.2 | Inadequate airport support | 0 | 1 | 1 |
| A.10 | Design | 10.1 | Design shortcomings | 0 | 0 | 0 |
| | | 10.2 | Unapproved modification | 0 | 0 | 0 |
| | | 10.3 | Manufacturing defect | 0 | 0 | 0 |
| A.11 | Performance | 11.1 | Unable to maintain speed/height | 0 | 0 | 0 |
| | | 11.2 | Aircraft becomes uncontrollable | 0 | 1 | 1 |
| A.12 | Other | 12.1 | Caused by other aircraft | 0 | 0 | 0 |
| | | 12.2 | Nonadherence to cabin safety procedures | 0 | 0 | 0 |

## Appendix 4.4
## Factors and Consequences Attributed to 19 Fatal Approach-and-landing Accidents in Eastern-built Turboprops *(continued)*

| B | Circumstantial Factor | | | Number of Times Cited in Accidents |
|---|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground-proximity warning system, traffic-alert and collision avoidance system, wind-shear warning, etc.) | 2 |
| | | 1.2 | Failure/inadequacy of safety equipment | 0 |
| B.2 | Air traffic control/Ground aids | 2.1 | Lack of air traffic control | 1 |
| | | 2.2 | Lack of ground aids | 6 |
| B.3 | Environmental | 3.1 | Poor visibility | 5 |
| | | 3.2 | Weather | 8 |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) | 0 |
| B.4 | Crew | 4.1 | Training inadequate | 0 |
| | | 4.2 | Presented with situation beyond training | 0 |
| | | 4.3 | Failure in Crew resource management (cross-check/coordinate) | 6 |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures | 1 |
| | | 5.2 | Company management failure | 6 |
| | | 5.3 | Inadequate regulation | 0 |
| | | 5.4 | Inadequate regulatory oversight | 7 |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight | 0 |

| C | Consequence | Number of Times Cited in Accidents |
|---|---|---|
| C.1 | Controlled flight into terrain (CFIT) | 6 |
| C.2 | Collision with terrain/water/obstacle | 9 |
| C.3 | Midair collision | 0 |
| C.4 | Ground collision with other aircraft | 0 |
| C.5 | Ground collision with object/obstacle | 2 |
| C.6 | Loss of control in flight | 6 |
| C.7 | Fuel exhaustion | 2 |
| C.8 | Overrun | 2 |
| C.9 | Undershoot | 2 |
| C.10 | Structural failure | 0 |
| C.11 | Postimpact fire | 2 |
| C.12 | Fire/smoke during operation | 0 |
| C.13 | Emergency evacuation difficulties | 0 |
| C.14 | Forced landing — land or water | 3 |
| C.15 | Other cause of fatality | 0 |

**Level of confidence** **8** **High** **7** **Medium** **1** **Low** **3** **Insufficient information**

# Appendix 4.5
## Factors and Consequences Attributed to 76 Fatal Approach-and-landing Accidents in Business Jets

| | | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| **A** | **Causal Factor** | | | **Primary** | **Causal** | **Total** |
| A.1 | Aircraft systems | 1.1 | System failure — affecting controllability | 1 | 0 | 1 |
| | | 1.2 | System failure — flight deck information | 1 | 1 | 2 |
| | | 1.3 | System failure — other | 0 | 0 | 0 |
| A.2 | Air traffic control/Ground aids | 2.1 | Incorrect or inadequate instruction/advice | 0 | 2 | 2 |
| | | 2.2 | Misunderstood/missed communication | 0 | 0 | 0 |
| | | 2.3 | Failure to provide separation in the air | 1 | 0 | 1 |
| | | 2.4 | Failure to provide separation on the ground | 0 | 0 | 0 |
| | | 2.5 | Ground aid malfunction or unavailable | 0 | 2 | 2 |
| A.3 | Environmental | 3.1 | Structural overload | 0 | 0 | 0 |
| | | 3.2 | Wind shear/upset/turbulence | 0 | 3 | 3 |
| | | 3.3 | Icing | 2 | 0 | 2 |
| | | 3.4 | Wake turbulence — aircraft spacing | 1 | 1 | 2 |
| | | 3.5 | Volcanic ash/sand/precipitation, etc. | 0 | 2 | 2 |
| | | 3.6 | Birds | 1 | 0 | 1 |
| | | 3.7 | Lightning | 0 | 0 | 0 |
| | | 3.8 | Runway condition unknown to crew | 0 | 0 | 0 |
| A.4 | Crew | 4.1 | Lack of positional awareness in the air | 15 | 29 | 44 |
| | | 4.2 | Lack of positional awareness on the ground | 0 | 0 | 0 |
| | | 4.3 | Lack of awareness of circumstances in flight | 0 | 1 | 1 |
| | | 4.4 | Incorrect selection on instrument/navaid | 3 | 1 | 4 |
| | | 4.5 | Action on wrong control/instrument | 0 | 0 | 0 |
| | | 4.6 | Slow/delayed action | 0 | 7 | 7 |
| | | 4.7 | Omission of action/inappropriate action | 23 | 11 | 34 |
| | | 4.8 | “Press-on-itis” | 4 | 8 | 12 |
| | | 4.9 | Failure in crew resource management (cross-check/coordinate) | 0 | 8 | 8 |
| | | 4.10 | Poor professional judgment/airmanship | 4 | 15 | 19 |
| | | 4.11 | Disorientation or visual illusion | 0 | 2 | 2 |
| | | 4.12 | Fatigue | 0 | 5 | 5 |
| | | 4.13 | State of mind | 0 | 1 | 1 |
| | | 4.14 | Interaction with automation | 0 | 0 | 0 |
| | | 4.15 | Fast and/or high on approach | 0 | 7 | 7 |
| | | 4.16 | Slow and/or low on approach | 1 | 34 | 35 |

## Appendix 4.5
## Factors and Consequences Attributed to 76 Fatal Approach-and-landing Accidents in Business Jets *(continued)*

| A | Causal Factor | | | Number of Times Cited in Accidents | | |
|---|---|---|---|---|---|---|
| | | | | Primary | Causal | Total |
| | | 4.17 | Loading incorrect | 0 | 2 | 2 |
| | | 4.18 | Flight handling | 7 | 9 | 16 |
| | | 4.19 | Lack of qualification/training/experience | 1 | 5 | 6 |
| | | 4.20 | Incapacitation/medical or other factors reducing crew performance | 2 | 0 | 2 |
| | | 4.21 | Failure in look-out | 1 | 0 | 1 |
| | | 4.22 | Deliberate nonadherence to procedures | 3 | 8 | 11 |
| A.5 | Engine | 5.1 | Engine failure or malfunction | 1 | 1 | 2 |
| | | 5.2 | Propeller failure | 0 | 0 | 0 |
| | | 5.3 | Damage due to noncontainment | 0 | 1 | 1 |
| | | 5.4 | Fuel contamination | 1 | 0 | 1 |
| | | 5.5 | Engine failure simulated | 0 | 0 | 0 |
| A.6 | Fire | 6.1 | Engine fire or overheat | 0 | 2 | 2 |
| | | 6.2 | Fire due to aircraft systems | 0 | 0 | 0 |
| | | 6.3 | Fire — other cause | 0 | 0 | 0 |
| | | 6.4 | Postimpact fire | 0 | 5 | 5 |
| A.7 | Maintenance/Ground handling | 7.1 | Failure to complete due maintenance | 0 | 0 | 0 |
| | | 7.2 | Maintenance or repair error/oversight/inadequacy | 0 | 0 | 0 |
| | | 7.3 | Ground staff or passenger(s) struck by aircraft | 0 | 0 | 0 |
| | | 7.4 | Loading error | 0 | 0 | 0 |
| | | 7.5 | Bogus parts | 0 | 0 | 0 |
| A.8 | Structure | 8.1 | Corrosion/fatigue | 0 | 0 | 0 |
| | | 8.2 | Overload failure | 0 | 0 | 0 |
| | | 8.3 | Flutter | 0 | 0 | 0 |
| A.9 | Infrastructure | 9.1 | Incorrect, inadequate or misleading information to crew | 1 | 2 | 3 |
| | | 9.2 | Inadequate airport support | 0 | 2 | 2 |
| A.10 | Design | 10.1 | Design shortcomings | 0 | 1 | 1 |
| | | 10.2 | Unapproved modification | 0 | 0 | 0 |
| | | 10.3 | Manufacturing defect | 0 | 0 | 0 |
| A.11 | Performance | 11.1 | Unable to maintain speed/height | 0 | 2 | 2 |
| | | 11.2 | Aircraft becomes uncontrollable | 0 | 1 | 1 |
| A.12 | Other | 12.1 | Caused by other aircraft | 0 | 0 | 0 |
| | | 12.2 | Nonadherence to cabin safety procedures | 0 | 2 | 2 |

## Appendix 4.5

## Factors and Consequences Attributed to 76 Fatal Approach-and-landing Accidents in Business Jets *(continued)*

| B | Circumstantial Factor | | | Number of Times Cited in Accidents |
|---|---|---|---|---|
| B.1 | Aircraft systems | 1.1 | Nonfitment of presently available safety equipment (ground-proximity warning system, traffic-alert and collision avoidance system, wind-shear warning, etc.) | 44 |
| | | 1.2 | Failure/inadequacy of safety equipment | 0 |
| B.2 | Air traffic control/Ground aids | 2.1 | Lack of air traffic control | 1 |
| | | 2.2 | Lack of ground aids | 25 |
| B.3 | Environmental | 3.1 | Poor visibility | 26 |
| | | 3.2 | Weather | 21 |
| | | 3.3 | Runway condition (ice, slippery, standing water, etc.) | 3 |
| B.4 | Crew | 4.1 | Training inadequate | 1 |
| | | 4.2 | Presented with situation beyond training | 2 |
| | | 4.3 | Failure in crew resource management (cross-check/coordinate) | 42 |
| B.5 | Infrastructure | 5.1 | Incorrect/inadequate procedures | 5 |
| | | 5.2 | Company management failure | 12 |
| | | 5.3 | Inadequate regulation | 3 |
| | | 5.4 | Inadequate regulatory oversight | 10 |
| B.6 | Other | 6.1 | Illegal/unauthorized/drug smuggling flight | 2 |

| C | Consequence | Number of Times Cited in Accidents |
|---|---|---|
| C.1 | Controlled flight into terrain (CFIT) | 39 |
| C.2 | Collision with terrain/water/obstacle | 30 |
| C.3 | Midair collision | 2 |
| C.4 | Ground collision with other aircraft | 0 |
| C.5 | Ground collision with object/obstacle | 5 |
| C.6 | Loss of control in flight | 14 |
| C.7 | Fuel exhaustion | 4 |
| C.8 | Overrun | 5 |
| C.9 | Undershoot | 12 |
| C.10 | Structural failure | 0 |
| C.11 | Postimpact fire | 20 |
| C.12 | Fire/smoke during operation | 2 |
| C.13 | Emergency evacuation difficulties | 0 |
| C.14 | Forced landing — land or water | 1 |
| C.15 | Other cause of fatality | 0 |

**Level of confidence** **35 High** **29 Medium** **10 Low** **2 Insufficient information**

# NTSB Reports 1997 U.S. Airline Accident Fatalities Lowest Since 1993

***The record improved between 1996 and 1997, even though passenger enplanements increased by 35 million in 1997. The number and rate of accidents classified as "major" by the U.S. National Transportation Safety Board also decreased from 1996 to 1997.***

*FSF Editorial Staff*

The number of fatalities in accidents involving air carriers operating under U.S. Federal Aviation Regulations (FARs) Part 121 was substantially lower in 1997 than in 1996, according to preliminary statistics released by the U.S. National Transportation Safety Board (NTSB).

The improvement was particularly notable because new U.S. Federal Aviation Administration (FAA) rules that went into effect in March 1997 expanded the Part 121 category to include operations using aircraft with 10 or more seats operating scheduled passenger service. Total passenger enplanements on airlines flying under Part 121 increased from 590 million in 1996 to 625 million in 1997.

There were two passenger fatalities in Part 121 service in 1997, compared with 319 passenger fatalities in 1996 (Table 1, page 43). A third fatality occurred in 1997 when a ground crew member was killed by the nosewheel of a wide-body aircraft. The number of passenger fatalities was the lowest since 1993, when there were none.

Part 121 airlines had two major accidents and four serious accidents in 1997, compared with six major accidents and none classified as serious in 1996 (Table 2, page 44, which includes NTSB category definitions). Major accidents dropped from 0.43 per million miles flown in 1996 to 0.13 in 1997.

There were 42 accidents on scheduled Part 121 air carriers — including those added to the category during the year — in 1997, compared with 32 the previous year (Table 3, page 45). Among those carriers, the 1997 accident rate rose for all accidents (from 0.395 per 100,000 departures in 1996 to 0.442 per 100,000 departures in 1997), but declined for fatal accidents (from 0.037 per 100,000 departures in 1996 to 0.032 per 100,000 departures in 1997).

Nonscheduled (charter) Part 121 airlines had seven accidents, one of them fatal, in 1997 (Table 4, page 46). That compared with six accidents, two of which were fatal, in 1996. The Part 121 nonscheduled airline accident rate increased from 1.59 per 100,000 departures in 1996 to 1.87 per 100,000 departures in 1997, but the Part 121 nonscheduled airline fatal accident rate declined from 0.53 per 100,000 departures to 0.27 per 100,000 departures during the same period.

Because random variation is an ever-present factor in the relatively small annual numbers of aviation accidents, changes from one year to the next may not be statistically significant.

## Table 1
## Passenger Injuries and Injury Rates, 1982 through 1997, For U.S. Air Carriers Operating Under FARs Part 121*

| Year | Passenger Fatalities | Passenger Serious Injuries | Total Passenger Enplanements (millions) | Million Passenger Enplanements per Passenger Fatality |
|---|---|---|---|---|
| 1982 | 210 | 17 | 299 | 1.4 |
| 1983 | 8 | 8 | 325 | 40.6 |
| 1984 | 1 | 6 | 352 | 352.0 |
| 1985 | 486 | 20 | 390 | 0.8 |
| 1986 | 4 | 23 | 427 | 106.8 |
| 1987 | 213 | 39 | 458 | 2.2 |
| 1988 | 255 | 44 | 466 | 1.8 |
| 1989 | 259 | 55 | 468 | 1.8 |
| 1990 | 8 | 23 | 483 | 60.4 |
| 1991 | 40 | 19 | 468 | 11.7 |
| 1992 | 26 | 14 | 494 | 19.0 |
| 1993 | 0 | 7 | 505 | No Fatalities |
| 1994 | 228 | 16 | 545 | 2.4 |
| 1995 | 152 | 15 | 561 | 3.7 |
| 1996 | 319 | 16 | 590 | 1.8 |
| See note below | | | | |
| 1997 | 2 | 21 | 625 | 312.5 |

*Since March, 20, 1997, includes aircraft with 10 or more seats formerly operated under Part 135.

FARs – U.S. Federal Aviation Regulations

Note: Injuries exclude flight crew and cabin crew.

Source: U.S. National Transportation Safety Board

## Table 2
## Accidents and Accident Rates by NTSB Classification, 1982 through 1997, For U.S. Air Carriers Operating Under FARs Part 121*

| | Accidents | | | | | Accidents per Million Hours Flown | | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Major | Serious | Injury | Damage | Aircraft Hours Flown (millions) | Major | Serious | Injury | Damage |
| 1982 | 3 | 4 | 6 | 5 | 7.040 | 0.426 | 0.568 | 0.852 | 0.710 |
| 1983 | 4 | 2 | 9 | 8 | 7.299 | 0.548 | 0.274 | 1.233 | 1.096 |
| 1984 | 2 | 2 | 7 | 5 | 8.165 | 0.245 | 0.245 | 0.857 | 0.612 |
| 1985 | 8 | 2 | 5 | 6 | 8.710 | 0.918 | 0.230 | 0.574 | 0.689 |
| 1986 | 4 | 0 | 14 | 6 | 9.976 | 0.401 | 0.000 | 1.403 | 0.601 |
| 1987 | 5 | 1 | 12 | 16 | 10.645 | 0.470 | 0.094 | 1.127 | 1.503 |
| 1988 | 4 | 2 | 13 | 10 | 11.141 | 0.359 | 0.180 | 1.167 | 0.898 |
| 1989 | 8 | 4 | 6 | 10 | 11.275 | 0.710 | 0.355 | 0.532 | 0.887 |
| 1990 | 4 | 3 | 10 | 7 | 12.150 | 0.329 | 0.247 | 0.823 | 0.576 |
| 1991 | 5 | 2 | 10 | 9 | 11.781 | 0.424 | 0.170 | 0.849 | 0.764 |
| 1992 | 3 | 3 | 10 | 2 | 12.360 | 0.243 | 0.243 | 0.809 | 0.162 |
| 1993 | 1 | 2 | 12 | 8 | 12.706 | 0.079 | 0.157 | 0.944 | 0.630 |
| 1994 | 4 | 0 | 12 | 7 | 13.124 | 0.305 | 0.000 | 0.914 | 0.533 |
| 1995 | 3 | 2 | 14 | 17 | 13.510 | 0.222 | 0.148 | 1.036 | 1.258 |
| 1996 | 6 | 0 | 18 | 14 | 13.963 | 0.430 | 0.000 | 1.289 | 1.003 |
| See note below | | | | | | | | | |
| 1997 | 2 | 4 | 24 | 19 | 15.290 | 0.131 | 0.262 | 1.570 | 1.243 |

*Since March 20, 1997, includes aircraft with 10 or more seats formerly operated under Part 135.

FARs – U.S. Federal Aviation Regulations
NTSB – U.S. National Transportation Safety Board

NTSB Accident Classifications:

Major: an accident in which any of three conditions is met:
- A Part 121 aircraft was destroyed;
- There were multiple fatalities; or,
- There was one fatality and a Part 121 aircraft was substantially damaged.

Serious: an accident in which either of two conditions is met:
- There was one fatality without substantial damage to a Part 121 aircraft; or,
- There was at least one serious injury and a Part 121 aircraft was substantially damaged.

Injury: A nonfatal accident with at least one serious injury and without substantial damage to a Part 121 aircraft.

Damage: An accident in which no person was killed or seriously injured, but in which any aircraft was substantially damaged.

Source: U.S. National Transportation Safety Board

## Table 3
## Accidents, Fatalities and Rates, 1982 through 1997, for U.S. Air Carriers Operating Under FARs Part 121, Scheduled Service (Airlines)*

| | Accidents | | Fatalities | | | | | Accidents per 100,000 Flight Hours | | Accidents per 1,000,000 Miles Flown | | Accidents per 100,000 Departures | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | All | Fatal | Total | Aboard | Flight Hours | Miles Flown | Departures | All | Fatal | All | Fatal | All | Fatal |
| 1982 | 16 | 4 | 234 | 222 | 6,697,770 | 2,806,885,000 | 5,162,346 | 0.224 | 0.045 | 0.0053 | 0.0011 | 0.291 | 0.058 |
| 1983 | 22 | 4 | 15 | 14 | 6,914,969 | 2,920,909,000 | 5,235,262 | 0.318 | 0.058 | 0.0075 | 0.0014 | 0.420 | 0.076 |
| 1984 | 13 | 1 | 4 | 4 | 7,736,037 | 3,258,910,000 | 5,666,076 | 0.168 | 0.013 | 0.0040 | 0.0003 | 0.229 | 0.018 |
| 1985 | 17 | 4 | 197 | 196 | 8,265,332 | 3,452,753,000 | 6,068,893 | 0.206 | 0.048 | 0.0049 | 0.0012 | 0.280 | 0.066 |
| 1986 | 21 | 2 | 5 | 4 | 9,495,158 | 3,829,129,000 | 6,928,103 | 0.211 | 0.011 | 0.0052 | 0.0003 | 0.289 | 0.014 |
| 1987 | 32 | 4 | 231 | 229 | 10,115,407 | 4,125,874,000 | 7,293,025 | 0.306 | 0.030 | 0.0075 | 0.0007 | 0.425 | 0.041 |
| 1988 | 28 | 3 | 285 | 274 | 10,521,052 | 4,260,785,000 | 7,347,575 | 0.257 | 0.019 | 0.0063 | 0.0005 | 0.367 | 0.027 |
| 1989 | 24 | 8 | 131 | 130 | 10,597,922 | 4,337,234,000 | 7,267,341 | 0.226 | 0.075 | 0.0055 | 0.0018 | 0.330 | 0.110 |
| 1990 | 22 | 6 | 39 | 12 | 11,524,726 | 4,689,287,000 | 7,795,761 | 0.191 | 0.052 | 0.0047 | 0.0013 | 0.282 | 0.077 |
| 1991 | 25 | 4 | 62 | 49 | 11,139,166 | 4,558,537,000 | 7,503,873 | 0.224 | 0.036 | 0.0055 | 0.0009 | 0.333 | 0.053 |
| 1992 | 16 | 4 | 33 | 31 | 11,732,026 | 4,782,825,000 | 7,515,373 | 0.136 | 0.034 | 0.0033 | 0.0008 | 0.213 | 0.053 |
| 1993 | 22 | 1 | 1 | 0 | 11,981,347 | 4,936,067,000 | 7,721,870 | 0.184 | 0.008 | 0.0045 | 0.0002 | 0.285 | 0.013 |
| 1994 | 19 | 4 | 239 | 237 | 12,292,356 | 5,112,633,000 | 7,824,802 | 0.146 | 0.033 | 0.0035 | 0.0008 | 0.230 | 0.051 |
| 1995 | 34 | 2 | 166 | 160 | 12,776,679 | 5,328,969,000 | 8,105,570 | 0.266 | 0.016 | 0.0064 | 0.0004 | 0.419 | 0.025 |
| 1996 | 32 | 3 | 342 | 342 | 13,188,456 | 5,499,206,000 | 8,092,429 | 0.243 | 0.023 | 0.0058 | 0.0005 | 0.395 | 0.037 |
| See notes below | | | | | | | | | | | | | |
| 1997 | 42 | 3 | 3 | 2 | 14,500,000 | 6,084,011,000 | 9,500,000 | 0.290 | 0.021 | 0.0069 | 0.0005 | 0.442 | 0.032 |

*Since March 20, 1997, includes aircraft with 10 or more seats formerly operated under Part 135.

FARs – U.S. Federal Aviation Regulations

Notes:

1997 data are preliminary.

Hours, miles and departures are compiled by the U.S. Federal Aviation Administration.

The 62 total fatalities in 1991 include the 12 persons killed aboard a Skywest commuter aircraft and the 22 persons killed aboard a USAir airliner when the two aircraft collided.

Suicide and sabotage cases are included in “Accidents” and “Fatalities” but are excluded from accident rates in this table.

Source: U.S. National Transportation Safety Board

## Table 4
## Accidents, Fatalities and Rates, 1982 through 1997, for U.S. Air Carriers Operating Under FARs Part 121, Nonscheduled Service (Airlines)

| | Accidents | | Fatalities | | | | | Accidents per 100,000 Flight Hours | | Accidents per 1,000,000 Miles Flown | | Accidents per 100,000 Departures | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | All | Fatal | Total | Aboard | Flight Hours | Miles Flown | Departures | All | Fatal | All | Fatal | All | Fatal |
| 1982 | 2 | 1 | 1 | 1 | 342,555 | 131,628,000 | 188,787 | 0.584 | 0.292 | 0.0152 | 0.0076 | 1.059 | 0.530 |
| 1983 | 1 | 0 | 0 | 0 | 383,830 | 148,409,000 | 209,112 | 0.261 | • | 0.0067 | • | 0.478 | • |
| 1984 | 3 | 0 | 0 | 0 | 429,087 | 169,153,000 | 232,776 | 0.699 | • | 0.0177 | • | 1.289 | • |
| 1985 | 4 | 3 | 329 | 329 | 444,562 | 178,264,000 | 237,866 | 0.900 | 0.675 | 0.0224 | 0.0168 | 1.682 | 1.261 |
| 1986 | 3 | 1 | 3 | 3 | 480,946 | 188,497,000 | 273,924 | 0.624 | 0.208 | 0.0159 | 0.0053 | 1.095 | 0.365 |
| 1987 | 2 | 1 | 1 | 1 | 529,785 | 234,647,000 | 308,348 | 0.378 | 0.189 | 0.0085 | 0.0043 | 0.649 | 0.324 |
| 1988 | 1 | 0 | 0 | 0 | 619,496 | 242,641,000 | 368,486 | 0.161 | • | 0.0041 | • | 0.271 | • |
| 1989 | 4 | 3 | 147 | 146 | 676,621 | 267,849,000 | 378,153 | 0.591 | 0.443 | 0.0149 | 0.0112 | 1.058 | 0.793 |
| 1990 | 2 | 0 | 0 | 0 | 625,390 | 258,545,000 | 296,545 | 0.320 | • | 0.0077 | • | 0.674 | • |
| 1991 | 1 | 0 | 0 | 0 | 641,444 | 266,287,000 | 311,002 | 0.156 | • | 0.0038 | • | 0.322 | • |
| 1992 | 2 | 0 | 0 | 0 | 627,689 | 272,091,000 | 365,334 | 0.319 | • | 0.0074 | • | 0.547 | • |
| 1993 | 1 | 0 | 0 | 0 | 724,859 | 313,402,000 | 351,303 | 0.138 | • | 0.0032 | • | 0.285 | • |
| 1994 | 4 | 0 | 0 | 0 | 831,959 | 365,485,000 | 417,525 | 0.481 | • | 0.0109 | • | 0.958 | • |
| 1995 | 2 | 1 | 2 | 2 | 733,387 | 322,246,000 | 359,633 | 0.273 | 0.136 | 0.0062 | 0.0031 | 0.556 | 0.278 |
| 1996 | 6 | 2 | 38 | 8 | 774,436 | 344,192,000 | 377,512 | 0.775 | 0.258 | 0.0174 | 0.0058 | 1.589 | 0.530 |
| 1997 | 7 | 1 | 5 | 4 | 790,000 | 357,900,000 | 375,000 | 0.886 | 0.127 | 0.0196 | 0.0028 | 1.867 | 0.267 |

FARs – U.S. Federal Aviation Regulations

Notes:

1997 data are preliminary.

Hours, miles and departures are compiled by the U.S. Federal Aviation Administration.

Source: U.S. National Transportation Safety Board

# Publications Received at FSF Jerry Lederer Aviation Safety Library

# Researchers Find That Redesigned Type III Exit Aids Evacuation in Test

***New book offers comprehensive overview of communication navigation surveillance, air traffic management (CNS/ATM) system that will be the basis of the future air navigation system (FANS).***

*FSF Editorial and Library Staffs*

## Reports

***The Design and Evaluation of an Improvement to the Type III Exit Operating Mechanism.*** Cobbett, A.M.; Jones, J.I.; Muir, H. U.K. Civil Aviation Authority (CAA) Paper no. 97006. September 1997. 69 pp. Tables, figures, appendices. Available through CAA.*

The Department of Aerospace Technology at Cranfield University was commissioned by the CAA in 1994 to evaluate the ease of use of the operating mechanism of Type III exits, and thus their accessibility for emergency aircraft evacuation. Type III exits are used on a wide variety of civil aircraft. These exits are different from airframe main doors because they are not supported or attached to hinges or other mechanisms.

Previous research and accident evidence have shown that many passengers have experienced difficulty in operating Type III exits when evacuating an aircraft. The weight of the hatch can be a factor (as much as [30.4 kilograms] 67 pounds on certain wide-body aircraft), in addition to lack of space, obstructions and the average passenger's unfamiliarity with the operation of the hatch.

For this study, a modified design was developed. The new design's engineering was practical for application to Type III exit locations in both narrow-body and wide-body aircraft. Tests were conducted to compare the conventional design with the modified operating mechanism to study the ease with which study participants were able to evacuate the aircraft cabin in a simulated emergency. Seating configuration changes adjacent to the exit were also assessed to evaluate any influence on the use of the Type III exit. The research discussed in this paper showed that the time needed to exit the aircraft was significantly reduced using the modified Type III exit design compared with the conventional design.

Appendices: (A) Procedure for Selection of Shortlisted Concepts; (B) Consideration of Five Shortlisted Concepts; (C) Considerations Leading to Final Concept Selection; (D) Diagram of the Modified Type III Exit; (E) Diagrams of the Two Seating Configurations; (F) Safety Placards; (G) Questionnaire; (H) Transcript of Preflight Briefing; (I) Emergency Evacuation Scenarios; (J) Raw Evacuation Times and Participant Demographics. [Adapted from Introduction and Conclusions.]

***Personality Characteristics of Pre/Post-Strike Air Traffic Control Applicants.*** Schroeder, David J.; Dollar, Carolyn S. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report no. DOT/FAA/AM-97/17. July 1997. 20 pp. Tables, figures, references, appendix. Available through NTIS.**

Keywords:
Air Traffic Controller Applicants
Personality
Post-ATC Strike
16PF

For more than 30 years, the FAA has used the 16 Personality Factors (16PF) test to identify potential psychological difficulties in air traffic control specialist (ATCS) applicants. The 16PF test was developed in 1949 by R.R. Cattell to measure aspects of normal adult personality. Recently, changes in ATCS recruitment efforts and the effects of the air traffic controllers' strike in 1981 have altered the pool of applicants. Previous recruitment efforts focused on former military air traffic controllers, while subsequent efforts have focused on attracting more women and minority applicants. This report is designed to examine the relationship between the personality characteristics of a group of poststrike ATCS applicants, studied in 1984, with a 1974 study by Karson and O'Dell, using data collected from the 1960s and early 1970s. Besides this comparison, the 1984 data can also provide a baseline from which to evaluate the characteristics of new air traffic controllers expected to enter the work force after the year 2000.

Results of the 1984 study were found to be consistent with findings from the 1974 study despite demographic changes. Male and female applicants had very similar personality profiles, and were found to be brighter than the average individual. When compared with the general population, the study also revealed ATCS applicants to be less anxious and more emotionally stable, self-disciplined and assertive.

Appendix A consists of descriptive information for the factors from the 16PF test profile, Karson and O'Dell and the Administrator's manual for the 16PF. [Adapted from Introduction and Conclusions.]

***A Flexible Cabin Simulator.*** Marcus, Jeffrey H. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report No. DOT/FAA/AM-97/18. August 1997. 19 pp. Figures. Available through NTIS.**

Keywords:
Passenger Aircraft Evacuation
Evacuation
Experimental Cabin Simulator

Aircraft cabin simulators are frequently used to conduct experimental research on emergency passenger evacuation. Normally, these simulators are configured to represent a typical airline passenger cabin, with research subjects attempting to evacuate as quickly as possible. Aspects of cabin design (such as the width of aisles) and operational procedures are varied so that the goal of cabin evacuation in the shortest possible time can be studied.

Nevertheless, certain limitations exist with current cabin simulators, which are usually either retired aircraft or other special-purpose simulators that duplicate only a single or limited number of aircraft. Because of this, new designs such as multideck, multiaisle megatransports cannot be simulated, thus restricting necessary research.

This report describes the requirements for a proposed flexible aircraft cabin simulator that is able to simulate any type of passenger aircraft cabin, from small commuter aircraft through jumbo transport. Features include a hydraulic positioning system, making door sill height adjustable; modular design, making it possible to fabricate cabin components such as exits; controlled interior and exterior lighting; and the use of nontoxic, vision-obscuring theatrical smoke. There is also a cabin-side pool to simulate an emergency water evacuation. Details and costs of the associated building are also discussed.

Contains many artist's conceptions of the proposed simulator and surrounding facility. [Adapted from Introduction and Summary.]

[See "Flexible Cabin Simulator Would Broaden Range of Cabin Evacuation Research," *Cabin Crew Safety*, July–August 1996.]

***Designing Selection Tests for the Future National Airspace System Architecture.*** Broach, Dana. U.S. Federal Aviation Administration (FAA) Office of Aviation Medicine. Report no. DOT/FAA/AM-97/19. August 1997. 12 pp. Figures, references. Available through NTIS.**

Keywords:
Selection
Air Traffic Control Specialist
Electronics Technician
Research Planning

There is a lack of empirical data that outlines the necessary abilities required to operate and maintain the emerging National Airspace System (NAS) architecture as described in the National Airspace Architecture version 2.0, produced by the FAA in 1996. This report describes the three-phase approach that the FAA is pursuing to identify the human abilities and performance requirements of the future NAS architecture, while addressing the challenges of cost, generational change and technological innovation in air traffic control and maintenance systems.

This effort involves the FAA Civil Aeromedical Institute (CAMI) Training and Organizational Research Laboratory's future selection-research program, which is designed to develop scientific tools and collect data to assess and evaluate the abilities likely to be required of future air traffic controllers, technicians and systems specialists. The first phase of the research program will develop a baseline profile describing the abilities required to use, operate and maintain the current NAS. The second phase will develop and apply scientific tools to identify changes in selection requirements in parallel with air traffic control and maintenance systems development. The third and final phase of the research program will develop, validate and deliver new personnel-selection technologies to reflect the human ability and performance requirements of the emerging NAS architecture. [Adapted from Introduction and Summary.]

***Aviation Safety: FAA Oversight of Repair Stations Needs Improvement.*** U.S. General Accounting Office (GAO). Report to Congressional Requesters, October 1997. Report no. GAO/RCED-98-21. 91 pp. Tables, figures, appendices. Available through GAO.***

Fleets operated by U.S. airlines and air cargo companies include more than 6,700 aircraft, almost 1,000 more than in 1990. Nearly half of the yearly maintenance, repair and renovation of this fleet is carried out by about 2,800 independent repair stations at a cost approaching US$6.5 billion a year. These stations are located worldwide and can range from some which employ a small staff and fix a limited number of components, to others employing thousands of workers who do everything from routine engine maintenance to rebuilding entire airframes.

Repair stations have been part of the industry for decades, but their use has greatly increased recently because of the many new carriers that find it more economical to contract out much of their maintenance work instead of building and staffing their own facilities. There has been recent concern about U.S. Federal Aviation Administration (FAA) oversight of repair stations because work performed by repair stations has been identified as being a contributing cause in several aircraft accidents, notably the accident involving a ValuJet DC-9 that was destroyed by an engine fire on a runway in June 1995.

This report set out to examine the following questions: (1) What is the nature and scope of the oversight of repair stations conducted by the FAA?; (2) how well does the FAA follow up on repair station inspections to ensure that identified deficiencies in the stations' operations are corrected?; and (3) what steps has the FAA taken to improve oversight of repair stations?

The following recommendations are made: (1) Increase the use of locally based inspection teams for repair station inspections, particularly for large, complex repair stations, those with higher rates of noncompliance or those that meet predetermined risk indicators. Develop and use checklists or job aids to bring about greater comprehensiveness and standardization; (2) specify the documentation to be kept in repair station files to record inspection results and follow-up actions; (3) monitor the implementation of the strategy for improving the quality of the data for the FAA's new management information system; and (4) expedite efforts to update regulations for the oversight of repair stations, while establishing and meeting schedules for completing the updates.

Includes three appendices: (I) Objective, Scope and Methodology, which outlines the airlines and repair stations included in this review; (II) Survey Methodology; (III) Survey Questions and Responses; and (IV) Major Contributors to This Report. [Adapted from Executive Summary and Results in Brief.]

# Books

***The Future Air Navigation System (FANS).*** Galotti, Vincent P. Brookfield, Vermont, United States: Ashgate Publishing Company, 1997. 362 pp.

The communication navigation surveillance, air traffic management (CNS/ATM) environment of the 21st century promises great benefits as new air routes are opened and more dynamic and flexible flight operations are accommodated all over the world. This concept for a future air navigation infrastructure is being developed by the nations of the world in association with the International Civil Aviation Organization (ICAO).

Although the concept's implementation is progressing, only technical manuals exist to describe the system's concept. Galotti's book is the first of its kind, entirely dedicated to the CNS/ATM systems concept. Further, it describes the world's vision for the future air navigation system (FANS) covering not just technical issues, but also institutional, economic, labor and human factors issues as well. Each chapter includes a summary along with questions and exercises, which makes this book suitable as a text for technical schools, high schools and universities. Professionals who implement, operate and further develop the new system will also find it important and comprehensive. Contains an index.

The author currently works for ICAO in Montreal, Quebec, Canada, as a technical officer, air traffic management, and he has worked as an air traffic controller for the U.S. Federal Aviation Administration (FAA) in the New York Air Route Traffic Control Center. [Adapted from Introduction and Foreword.]

***Aviation Safety and Pilot Control: Understanding and Preventing Unfavorable Pilot-Vehicle Interactions.*** National Research Council. Washington, D.C., United States: National Academy Press, 1997. 208 pp.

Aircraft-pilot coupling (APC) events usually occur when a pilot is occupied with a highly demanding "closed-loop" control task, such as during air-to-air refueling operations or approaches and landings, particularly if the pilot is concerned about bad weather, low on fuel or other circumstances. Adverse APC events are rare, unintended and unexpected oscillations or divergences of the pilot-aircraft system, and can cause mismatches between actual and expected aircraft responses.

Some recent accidents and incidents, both military and civilian, have been attributed to adverse APC. To address this situation, the National Research Council, at the request of the U.S. National Aeronautics and Space Administration (NASA), established the Committee on the Effects of Aircraft-Pilot Coupling on Flight Safety. The committee evaluated the current state of knowledge about adverse APC and the processes that may be used to eliminate it. This book consists of findings and recommendations developed by the committee based on the information it collected and analyzed.

Findings and recommendations were submitted for consideration to the U.S. Air Force, U.S. Navy and U.S. Army; NASA; and the U.S. Federal Aviation Administration (FAA). The committee concluded that in the short term, the risk presented by adverse APC could be reduced by increased awareness of APC possibilities and more disciplined application of existing tools and capabilities throughout the aircraft development, testing and certification process. Many advanced aircraft designs require new methods to address APC risk. To develop these new methods, the committee concluded that long-term efforts are needed in the area of APC assessment criteria, analysis tools and simulation capabilities.

Appendices: (A) Biographical Sketches of Committee Members; (B) Participants in Committee Meetings; (C) Details of Aircraft-Pilot Coupling Examples; and (D) Research. Also includes a glossary. [Adapted from Preface and Executive Summary.]

***When the Airlines Went to War.*** Serling, Robert J. New York, New York, United States: Kensington Publishing Corp., 1997. 310 pp.

Robert J. Serling is a well-known aviation author who also wrote the bestseller, *The President's Plane is Missing. When the Airlines Went to War* tells the story of how America's domestic airlines, including American Airlines, Trans World Airlines, United Airlines and Pan American World Airways, contributed to the U.S. military war effort in World War II. Exchanging their civilian colors for olive drab, these domestic airlines gave up half their fleets and their most skilled pilots, mechanics and engineers. Extending their skills and endurance levels to the limit, crews carried cargo ranging from troops to ammunition, medicine, spies and dogsled teams. Aircraft were kept operating by mechanics who sometimes borrowed parts from visiting planes, or even fashioned parts from scrap metal and tin cans. The book describes what life was like for crews inside the transports, and for airmen on secret and dangerous missions across the globe. There are accounts of meetings between the airline owners and the staff of U.S. President Franklin Delano Roosevelt's White House as they developed the Air Transport Command (ATC) and Naval Air Transport Service (NATS).

The author gives grateful acknowledgment to Jerry Lederer, the President/Emeritus of Flight Safety Foundation, for providing background information on the development of the airlines' wartime training schools, which he helped to establish. [Adapted from inside cover and Acknowledgments].♦

## Sources

*U.K. Civil Aviation Authority (CAA)
Printing and Publications Services
Greville House
37 Gratton Road
Cheltenham GL50 2BN England

**National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161 U.S.
(703) 487-4600

***U.S. General Accounting Office (GAO)
P.O. Box 6015
Gaithersburg, MD 20884-6015 U.S.
Telephone: (202) 512-6000; Fax: (301) 258-4066

## Updated Regulations and Reference Materials

### U.S. Federal Aviation Administration Advisory Circulars (ACs)

| AC No. | Date | Title |
|---|---|---|
| 183.29-1FF | 12/18/97 | *Designated Engineering Representatives Consultant Directory.* (Cancels AC 183.29-1EE, *Designated Engineering Representatives,* dated Dec. 18, 1996.) |

### International Reference Updates

***Aeronautical Information Publication* (A.I.P.) Canada**

| Amendment No. | Date | |
|---|---|---|
| 2/98 | 23 April 1998 | Updates the General, Aerodromes, Meteorology, Rules of the Air and Air Traffic Services, and Airmanship sections of the A.I.P. |

**Airclaims**

| Update No. | Date | |
|---|---|---|
| 107 | 27 March 1998 | Updates *Major Loss Record.* Worldwide aircraft accident summaries through early March 1998. |

**Joint Aviation Authorities (JAA)**

| Reference No. | Date | |
|---|---|---|
| 01/13-5 | 1 February 1998 | Revision to JAA Administrative and Guidance Material — Section Three — Certification. |

# Accident/Incident Briefs

# Incorrect Altimeter Setting Puts Aircraft on Approach at 74 Meters above Field Elevation While Eight Kilometers from Runway

***Emergency helicopter strikes power line, killing pilot, nurses and accident victim who was being transported to trauma center.***

*FSF Editorial Staff*

*The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.*

## Wind-shear Alert in Clear Weather

*Boeing 767-300. Substantial damage. No injuries.*

The aircraft was in the final stage of a manually flown, daylight instrument landing system (ILS) approach to an eastern U.S. airport. The weather was clear, with winds of (30 kilometers per hour [kph] gusting to 46 kph) 16 knots gusting to 25 knots. About five seconds before expected touchdown, at an altitude of nine meters (30 feet) above the ground, a wind-shear alert sounded in the cockpit.

There was no recorded aft movement of the aircraft's control column during the alert until about one second to two seconds before touchdown.

The aircraft touched down hard (+1.9 Gs) and bounced. While airborne, the aircraft's ground spoilers partially deployed and then stowed again. The second touchdown was harder (+2.8 Gs), but the aircraft stayed on the ground and was brought to a halt on the runway.

The approach was flown by the copilot, who had 68 hours in type.

## Pilot Aborts Takeoff Without Autothrottles

*McDonnell Douglas MD-82. Substantial damage. No injuries.*

The runway at the Asian airport was (3,300 meters) 10,800 feet long; it was wet from light rain and had been described as "slick."

During the takeoff, just before reaching $V_1$, the aircraft's autothrottles tripped off. The captain elected to abort the takeoff, but he was unable to stop the aircraft before the end of the runway.

The pilot steered the aircraft to the left, toward a taxiway, in an effort to avoid an overrun; but the aircraft began to skid sideways and came to rest on its fuselage, about (170 meters) 558 feet beyond the runway end.

## Cargo Compartment Fire Forces Landing

*Boeing 747. Minor damage. No injuries.*

The aircraft was on a scheduled international flight when a fire occurred in the cargo section. The captain used the aircraft's emergency systems to extinguish the fire. He then requested clearance for an unscheduled landing. The aircraft landed without further incident at 0500 local time.

Airport officials said that the fire had been caused by an electrical fault, but gave no details. There were no casualties on board the aircraft.

Air Taxi
Commuter

## Pilot Ignores Warning Horn

*Beech B100 King Air. Damage unknown. No injuries.*

The pilot had landed 20 minutes earlier at a western U.S. airport; on his approach to the airport, there had been three green lights on the aircraft's instrument panel, indicating that the landing gear was down and locked.

While taxiing for takeoff, the landing-gear warning horn sounded. The pilot adjusted the squat switch to silence the horn, and then made a test flight to check the adjusted system.

During the subsequent landing, the left-main landing gear collapsed on rollout, and the aircraft veered off the runway and collided with a sign.

## Damage Happened after the Landing

*Beech B200 King Air. Substantial damage. No injuries.*

While en route, the pilot became concerned about his aircraft's fuel state and elected to divert. Weather was marginal, with a (214-meter) 700-foot ceiling and visibility of (488 meters) 1,600 feet in fog.

The pilot made an ILS approach, but landed about (1,000 meters) 3,281 feet short of the runway.

The aircraft had apparently suffered little or no damage. When the pilot decided to taxi forward onto the runway, the aircraft's nose wheel rolled into a hole and substantial damage occurred to the aircraft.

## Cargo Aircraft Fails to Stay Airborne

*Fokker F-27. Aircraft destroyed. One fatal, five serious injuries.*

The cargo-configured aircraft took off from Runway 06 at an African airport in daylight and visual meteorological conditions (VMC). The aircraft's landing gear was seen to retract immediately after the aircraft became airborne. The aircraft then settled back onto the runway in a right-wing-low attitude, and the right wing and no. 2 propeller struck the ground.

The aircraft continued to slide on its fuselage, off the end of the runway and across rough ground, finally coming to rest about (300 meters) 984 feet beyond the end of the runway.

Areas under investigation as the possible causes of the accident include errors in the takeoff weight-and-balance calculations and the possibility of cargo shifting on takeoff.

Corporate
Executive

## Crosswind Landing in Strong Winds Taxes Pilot

*Cessna 650 Citation III. Substantial damage. No injuries.*

Following a normal ILS approach to Runway 04 in daylight and clear weather, the aircraft touched down on its left-main landing gear. Then its right-main landing gear made contact, and the aircraft bounced into the air before touching down again.

After a further ground run of (91 meters to 122 meters) 300 feet to 400 feet, the left-main landing gear collapsed and the left wing hit the runway.

The wind was from 120 degrees at (46 kilometers per hour) 25 knots, a right-hand crosswind of almost 90 degrees.

## Airport Utility Vehicle Stalls On Runway, Hit by Landing Aircraft

*Gulfstream Aerospace Gulfstream II. Aircraft destroyed. No injuries.*

On a night landing in clear weather, the aircraft collided with an airport utility vehicle that had stalled on the runway.

The crew of the utility vehicle had been cleared onto Runway 31 about 40 minutes earlier to work on the runway centerline lights. Some time after that the vehicle became disabled. The aircraft had been cleared to land by the tower local controller when the aircraft was about (19 kilometers) 12 miles from the airport.

One of the men in the vehicle saw the approaching aircraft and radioed the tower that the vehicle was on the runway. After making more unsuccessful attempts to start the vehicle, the two men abandoned the vehicle and ran to safety.

The aircraft landed uneventfully. It was rolling out and reverse thrust had been applied when the tower instructed the aircraft to go around. The crew of the Gulfstream advised the tower that they had already landed.

Shortly thereafter, the crew of the Gulfstream saw the utility vehicle parked on the runway centerline. They tried to turn left to avoid the vehicle, but they were not successful; the right wing of the Gulfstream struck the utility vehicle.

## Loss of Engine Power Ends in Loss of Aircraft

*Learjet 35A. Aircraft destroyed. No injuries.*

The aircraft was taking off in daylight on Runway 21. As the aircraft approached $V_1$, the left engine lost power; the aircraft veered off the runway about (793 meters) 2,600 feet from where it began the takeoff.

The aircraft then became airborne and climbed to an altitude of (15 meters to 23 meters) 50 feet to 75 feet before settling back onto the runway surface about (305 meters) 1,000 feet farther down the runway.

The weather was visual meteorological conditions, with the wind from 260 degrees at (13 kilometers per hour gusting to 35 kilometers per hour) seven knots gusting to 19 knots.


## Bad Weather and High Terrain Prove Dangerous Combination

*Unidentified light aircraft. Aircraft destroyed. Two fatalities.*

The pilot was approaching his destination, a mountain airport in South America. When he learned that the airport was closed because of heavy rain and restricted visibility, the pilot was forced to make a 180-degree turn.

Air traffic controllers lost contact with the aircraft shortly after that. The next day the wreckage of the aircraft was found in the mountainous terrain. It was determined that after the U-turn, the aircraft flew into the mountain.

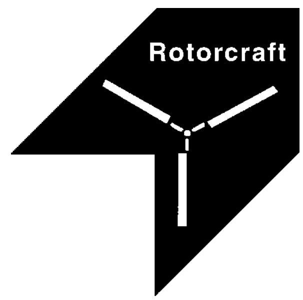
## Engine Overspeed Causes Aircraft to Leave Runway

*Cessna 441. Aircraft destroyed. No injuries.*

During the takeoff roll in daylight and clear weather, the aircraft's right engine began to overspeed. The aircraft veered to the left.

The pilot attempted to abort the takeoff, but the right wing lifted, and the aircraft departed the runway in a nose-down, left-wing-low attitude. Impact with the ground collapsed the landing gear, and the aircraft spun around several times before coming to a stop.

Fire destroyed the aircraft.




## Helicopter Clips Hedge in Forced Landing

*Bell 206 LongRanger IV. Substantial damage. Five injuries.*

The privately owned helicopter was required to make an off-airport landing, during which the aircraft clipped a hedge and made contact with the ground. The five occupants of the helicopter, one of whom was seriously injured, were taken to the hospital.

## Impact with Power Pole Downs Helicopter

*Unknown type. Aircraft destroyed. Three fatalities.*

A four-member crew aboard the helicopter was stretching wire across a river when the helicopter contacted a power pole.

One of the helicopter rotors struck a worker on the power pole and knocked him to the ground, fatally injured. The helicopter then fell into the river. The impact with the water killed the pilot and one of the passengers. The two remaining passengers were taken to a hospital, where one was listed in serious condition. No one on the ground was hurt.

The time of day and the weather at the time of the accident were not reported.

## Loss of Tail Rotor Sends Helicopter Out of Control

*Unknown type. Aircraft destroyed. Two fatalities.*

After losing its tail rotor, the helicopter plummeted nose-first into a field and burst into flames. Witnesses tried to pull the two occupants of the helicopter from the wreckage, but were repelled by the flames.

The identity of the two men in the helicopter and the helicopter's owner had not been established at the time of the accident report.

No information was given on the time the accident occurred or the weather at the time of the accident.

## Uncontained Engine Failure Damages Second Engine

*Aérospatiale AS332L1 Super Puma. Aircraft destroyed. Twelve fatalities.*

The crew of the Super Puma was transferring 10 passengers from a land base (200 kilometers) 108 nautical miles to a North Sea oil platform. Routine communications between the aircraft and the oil platform continued until five minutes before the helicopter's expected arrival time. About (31 kilometers) 17 nautical miles from its destination, the aircraft struck the sea. Unconfirmed reports indicate that an uncontained failure of the no. 2 engine's power-turbine stages was caused by a failure of the no. 2 engine's Bendix shaft. Debris from the no. 2 engine passed through the no. 1 engine and the cabin roof, and also damaged the helicopter flight controls. The crew lost control and the helicopter began to break up.

## Medevac Helicopter Destroyed by Medical-oxygen Cylinder Explosion

*Bell 206L3 Long Ranger. Aircraft destroyed. One serious injury.*

After arriving at the scene of an ultralight-aircraft accident, the pilot of the Long Ranger medical evacuation helicopter secured the aircraft's engine and electrical power. While the medical technicians attended to the injuries of the ultralight's occupants, the pilot prepared the helicopter for departure. Immediately after the pilot opened the valve of the medical oxygen-supply cylinder, which was housed in the luggage compartment, a large explosion occurred. Inspection revealed that the high-pressure hose that leads from the oxygen cylinder to the oxygen-pressure gauge in the aft cabin contained traces of welding slag and flux material. The hose failed because of internal burning at a point about (7.62 centimeters) three inches from the point at which the hose attaches to the cylinder.

## Long-line Operation Ends in Landing Accident

*Aérospatiale SA 319B Astazou Alouette III. Aircraft substantially damaged. One minor injury.*

The aircraft was moving an external load with a long line into a site located (1,983 meters) 6,500 feet above sea level. Not satisfied with his first approach to the landing area, the pilot waved off and approached from the opposite direction. As the aircraft descended on approach, the pilot increased the collective. The aircraft shuddered, rotor revolutions per minute (RPM) decayed and the rate of descent increased. After striking the ground, the helicopter rolled onto its right side. At the time of the report, it was suspected that the aircraft settled with power.

## Underslung Cable Complicates Landing Following Hydraulic-pressure Loss

*Aérospatiale AS350B2 Ecureuil. Damage unknown. No injuries.*

A geophysical survey was being conducted using equipment carried on an underslung cable and weighing (431 kilograms) 950 pounds. After the aircraft suffered an in-flight loss of hydraulic pressure, the pilot elected to return to base with the geophysical equipment still attached. When the pilot began to drop the underslung equipment to land the aircraft, the nose of the aircraft began to rise as tension was released from the cable.

The pilot turned the helicopter to land behind the equipment when tension unexpectedly returned to the cable and caused the geophysical equipment to be dragged through a snow drift. Control of the helicopter was momentarily lost, and the aircraft descended. The aircraft's tail stinger struck the ground and the helicopter ascended. The cable to the geophysical equipment came under tension again and the helicopter descended in a nose-low attitude over an embankment. The main rotors struck both the ground and the tailboom, but the aircraft did not roll over.

Inspection revealed that the hydraulic-pressure loss was caused by a failure of a hydraulic-pump drive belt at a seam in the belt. The belt, which is normally changed at 600 hours, had been in use for 250 hours at the time of the accident. The operator had inspected the belt's condition and tension daily prior to the accident.♦

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# Disaster Response Planning Workshop for Business Aviation

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